MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

EDITORIAL STAFF

Laurence E. Jermy, Editor

John W. Greve, Managing Editor

Associate Editors

Colin Carmichael Richard K. Lotz

Roger W. Bolz

Harry Raech Jr., Assistant Editor

Frank H. Burgess, Art Editor

New York . . . B. K. Price, L. E. Browne
Chicago . . . . . Erle F. Ross
Pittsburgh . . . . . J. C. Sullivan
Detroit . . . . . A. H. Allen
Washington . . . . . E. C. Kreutzberg
London . . . . . Vincent Delport

BUSINESS STAFF

G. O. Hays, Business Manager

Mary L. Callahan, Advertising Service
Chicago . . . . . H. H. Dreyer, Manager
J. M. Wells, Ass't. Manager
New York . . . . . R. H. Smith, Manager
E. S. Lawson, Ass't. Manager
Cleveland . . . . . H. B. Veith, Manager
Los Angeles . . . . . F. J. Fuller, Manager

CIRCULATION & RESEARCH

J. W. Zuber, Director
Jack C. Gernhard, Readers Service
R. L. Hartford, Market Research

MAIN OFFICE

Penton Building, Cleveland 13, Ohio

BRANCH OFFICES

New York 17 . . . . . 16 East 43rd St.
Chicago 11 . . . . . 520 North Michigan Ave.
Pittsburgh 19 . . . . . 2806 Koppers Building
Detroit 2 . . . . . 6560 Cass Ave.
Washington 4 . . . . . 1123 National Press Bldg.
Los Angeles 4 130 N. New Hampshire Ave.
London, S.W.1 2 Caxton St., Westminster

Published by The Penton Publishing Co. E. L. Shaner, Pres. and Treas.; G. O. Hays, Vice Pres. and Gen. Mgr.; R. C. Jaenke, Vice Pres.; F. G. Steinebach, Vice Pres. and Secy.; E. L. Werner, Asst. Treas. Published on the seventh of each month.

This Month's Cover: The noiseless typewriter depicted, a Remington Rand model, is typical of modern office machines which lessen the burden of work and increase the efficiency of operators.

CONTENTS

May, 1948 Vol. 20, Number 5

Investment Castings—tips on designing for reasonable cost 91
By W. O. Sweeney and H. L. Mattes

Scanning the Field for Ideas 98

Constant Velocity Joints—how and why they operate as they do 101
By H. H. Mabie

Elastic Matching Improves Bearing Life and Performance 106
By J. G. Baker

Production Processes—Part XXXIII—Grinding, Design Factors 111
By Roger W. Bolz

Turbine-Electric Locomotive—employs unique arrangement 118

Air-Driven Spinners—for testing fast-rotating machine components 121
By L. W. Wightman

Cutting Production Costs? Watch Design Details! 126
By A. F. Murray

Inverted Relief Valves—provide positive action 129
By H. G. Conway

Low-Torque Potentiometers—simplify control problems 134
By H. D. Wright

Program Controls—a guide to their selection 137
By Albert M. Patterson

Assures Accurate Positioning 144
By A. T. Bachelor

No Time To Waste! (Editorial) 145

Calculating Deflections of Hollow Shafts in Torsion (Data Sheet) 151
By Carl P. Nachod

Itemized Index 7
Topics 86
Designs of the Month 146
Applications of engineering parts, materials and processes 150
Assets to a Bookcase 153
New Parts and Materials 154
Engineering Dept. Equipment 166
Men of Machines 170
Noteworthy Patents 174
Business and Sales Briefs 182
Meetings and Expositions 189
Design Abstracts 190
New Machines 198
Helpful Literature 253

Subscription in the United States and possessions, Canada, Cuba, Mexico, Central and South America: One year $10. Single copies, $1.00. Other Countries One year, $15.

Copyright 1948 by The Penton Publishing Company.

Acceptance under Act of June 5, 1934 Authorized July 20, 1934

Production gaging with External Comparator No. 951 and Amplifier No. 950.

NEW! *Electronic* MEASURING EQUIPMENT by Brown & Sharpe

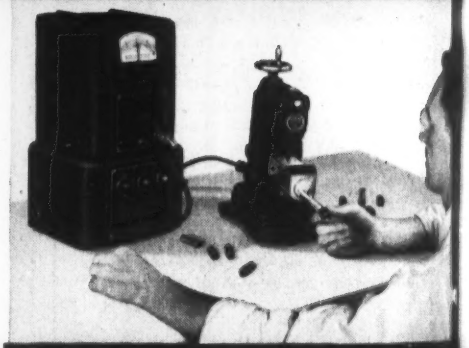
● EXTERNAL ● INTERNAL

Precision gaging on a mass-production scale is now both practical and economical for any plant or laboratory! The new Brown & Sharpe Electronic Measuring Equipment applies electronic super-sensitivity to measurement, and electronically amplifies the results for instant, accurate reading on a large calibrated dial. It enables accurate gaging to .00001", as fast as test-pieces can be handled.

An outstanding advantage of this new Electronic Measuring Equipment is the separate amplifier unit, which isolates heat-producing elements and prevents temperature drift in gaging units. Another unique feature is the true linear response of the gaging units, which permits accurate setting for the entire scale with only one gage block or master. These are only two of *many* advantages.

Get the full story of this versatile new Electronic Measuring Equipment. Write for details. Brown & Sharpe Mfg. Co., Providence 1, R. I., U.S.A.

We urge buying through the Distributor



Speedy internal gaging with Internal Comparator Attachment No. 952, Amplifier No. 950 and Signal Light Attachment No. 958 (optional).

Gage Head Cartridge No. 953 is shown mounted in special fixture for linear gaging.

BROWN & SHARPE

Itemized Index

Classified for convenience when studying specific design problems

Design and Calculations

Automatic flame hardener, design features, Edit. 148-149
Castings, investment, design factors, Edit. 91-97
Centerless grinder, design features, Edit. 146-147
Clutch, electromagnetic, Edit. 99
Elastic matching, designing for, Edit. 106-110
Gaging, x-ray, for thickness, Edit. 100
Grinding, design factors, Edit. 111-117
Joints, constant velocity, Edit. 101-105
Locomotive, turbine-electric, Edit. 118-120
Positioning control, Edit. 144, 180
potentiometer controls, design of, Edit. 134-136
Production costs, reducing, Edit. 126-128
Program controls, selection of, Edit. 137-143
Shaft deflection nomogram, (data sheet), Edit. 151-152
Spinners, air-driven, Edit. 121-125
Three-dimensional pantograph, design features, Edit. 147-148
Valves, inverted relief, Edit. 129-133

Engineering Department

Equipment, Edit. 166, 168; Adv. 29, 161
Instruments, Edit. 168
Supplies, Adv. 21, 178, 195, 258
Testing equipment, Edit. 166, 168; Adv. 48, 199

Finishes

Enamel, porcelain, Edit. 190
Protective coating, Adv. 246

Materials

Aluminum alloys, Edit. 164; Adv. 165
Brass, Adv. 35-36, 203
Copper alloys, Edit. 155; Adv. 14, 263
Friction materials, Adv. 251
Glass cloth, Adv. 197
Laminated metals, Adv. 17, 89
Laminates, Adv. 176, 219-220
Magnesium alloys, Edit. 196; Adv. 249
Magnetic, Adv. 171
Molybdenum alloys, Adv. 194
Nickel alloys, Adv. 19, 46, 179, 185
Plastics, Edit. 150, 157, 158, 164; Adv. 207, 269
Rubber and synthetics, Adv. 6, 205
Silicones, Adv. 69, 172
Steel, Edit. 192; Adv. 12, 45, 181, 267
Steel stainless, Adv. 24, 44
Tungsten, Adv. 256

Parts

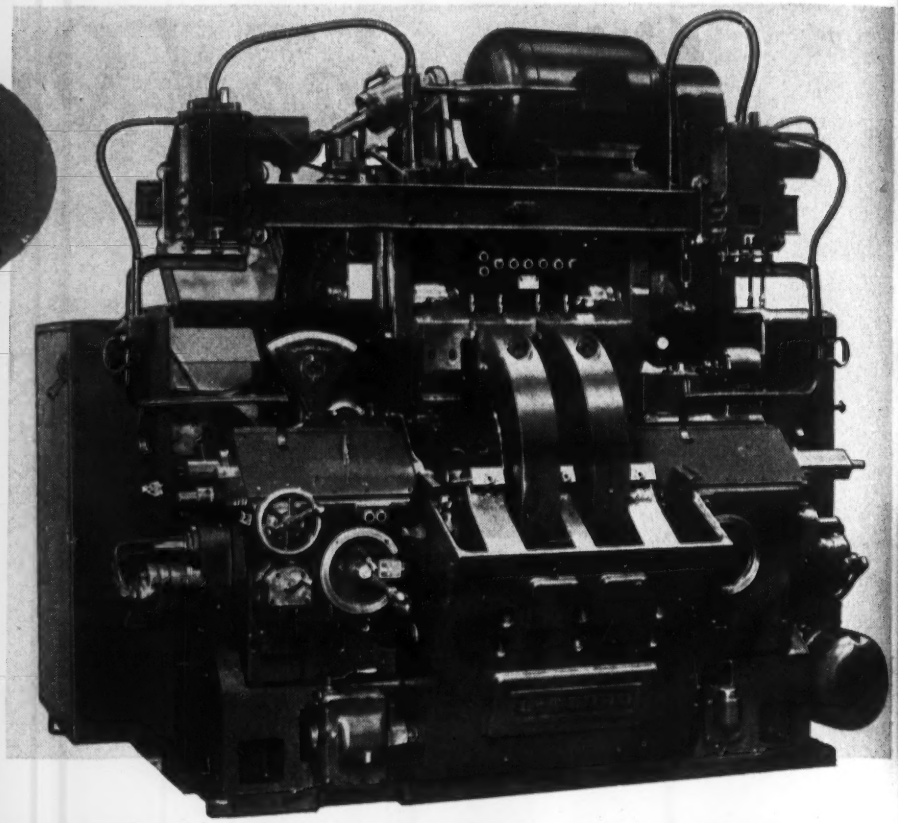
Balls, Edit. 162; Adv. 270, 277
Bearings:
  Ball, Adv. 6, 53, 257, 261, 267, 278
  Needle, Adv. 191
  Roller, Adv. 11, 57, 235, 238, 258, 285
  Sleeve, Adv. 25, 82, 159, 175, 210, 229, 237
Belts, Edit. 157; Adv. 25, 167, 242
Bimetal parts, Edit. 174
Brakes, Adv. 64
Brushes, Adv. 80
Bushings, Adv. 266, 280
Carbon parts, Adv. 39, 279
Castings:
  Die, Edit. 126-128
  Investment, Edit. 91-97
  Sand, Adv. 192, 214
Chains:
  Roller, Adv. 5, 42, 43, 54, 232
  Silent, Edit. 158, 160
Clutches, Edit. 99; Adv. 13, 37, 226, 255, 260, 276
Collars, Adv. 268
Compressors, Adv. 204
Controls (see Electric)
Conveyors, Adv. 180, 274
Counters, Adv. 83
Diaphragms, Adv. 169
Electric accessories, Edit. 156; Adv. 184, 221, 258, 269
Electric controls:
  Capacitors, Edit. 164
  Contactors, Adv. 188
  Contacts, Adv. 275
  Control assemblies, Edit. 136, 137, 144, 153, 180; Adv. back cover
  Potentiometers, low-torque, Edit. 134-136
  Relays, Edit. 160, 162; Adv. 236
  Solenoids, Adv. 245
  Starters, Adv. 40, 189
  Switches, Edit. 154, 155, 156; Adv. 66-67
  Thermostats, Edit. 174; Adv. 18
  Timers, Edit. 138, 139, 164, 178
Electric drives, Edit. 118-120
Electric heating units, Adv. 267
Electric motors, Edit. 98, 154, 156, 157, 158, 160, 162, 164; Adv. 1, 8, 15, 27, 50-51, 58-59, 62-63, 70, 73, 78, 81, 85, 90, 173, 212-213, 222, 243, 262, inside back cover
Engines, Edit. 154; Adv. 186, 260, 264, 269, 270, 273, 275
Fans, Edit. 158
Fastenings:
  Blind, Edit. 155; Adv. 61, 202
  Locking, Edit. 164; Adv. 32-33, 60, 77, 218, 277
  Nuts, bolts, screws, Adv. 76, 87, 163, 174, 182, 211, 265, 271, 273, 281, 283, 286
Felt parts, Adv. 262
Filters, Adv. 31, 271
Fittings, Adv. 247
Forgings, Adv. 227, 270
Gears, Edit. 133; Adv. 23, 196, 216, 234, 266, 274, 278
Governors, Edit. 178
Heating units, (see Electric heating units)
Hose (see Tubing)
Hydraulic and pneumatic equipment:
  Accumulators, Adv. 228
  Couplings, Edit. 155
  Pumps, Edit. 157, 174; Adv. 9, 230, 250, 268, 276
Systems, Edit. 142, 176, 178
Valves, Edit. 129-133, 155, 158, 174; Adv. 55, 200, 202, 223, 273, 280
Joints, Edit. 160; Adv. 279
Joints:
  Ball, Adv. 262
  Universal, Edit. 101-105; Adv. 224, 256
Lamps and lighting, Edit. 155
Lubrication and equipment, Edit. 154, 160; Adv. 52, 273
Machined parts, Adv. 198
Magnetos, Adv. 41
Motors (see Electric motors)
Mountings, rubber, Adv. 177, 259
Nameplates, Adv. 208
Piping and equipment, Adv. 28
Pneumatic equipment (see Hydraulic and pneumatic)
Powder-metal parts, Edit. 153
Pulleys and sheaves, Edit. 158; Adv. 280
Pumps (see also Hydraulic and pneumatic), Edit. 156, 176; Adv. 65, 272
Rings, Adv. 215
Rubber and synthetic parts, Adv. 74
Seals, packings, gaskets, Adv. 2, 38, 49, 56, 194, 201, 225, 233, 248, 252, 266
Shafts, Edit. 151-152
Shafts, flexible, Adv. 268
Speed reducers, Edit. 157; Adv. 183, 209, 277
Spindles, Adv. 30
Springs, Adv. 22, 187, 260, 264
Stampings, Edit. 126-128; Adv. 26, 240, 275
Transmissions, Adv. inside front cover, 34
Transmissions, variable speed, Edit. 150; Adv. 16, 84, 264
Tubing:
  Flexible, Adv. 47, 198
  Metallic, Edit. 156; Adv. 71-72, 88, 194, 231, 239, 244
Turbines, air, Edit. 121-125
Valves (see also Hydraulic and pneumatic), Adv. 279
Weldments and equipment, Edit. 106-110; Adv. 20, 68, 206
Wheels and casters, Adv. 190
Wire and wire products, Adv. 276

Production

Boring machines, Adv. 217
Broaching, Edit. 150
Gaging, x-ray, Edit. 100
Grinding, Edit. 111-117
Honing, Adv. 79
Machines, special Adv. 241
Stamping, Edit. 153; Adv. 79
Testing and equipment, Adv. 4

MACHINE DESIGN is indexed in Industrial Arts Index and Engineering Index Service, both available in libraries generally

Wagner Motors on the job . . .



Wagner type CP totally-enclosed, fan-cooled motors applied to a crankshaft lathe, used in an automobile manufacturing plant.

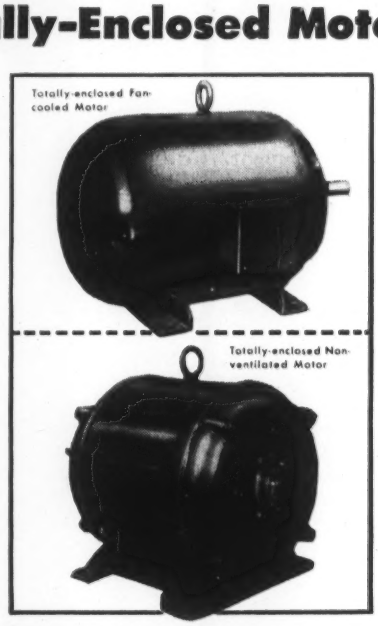
. . . KEEP MOTOR FAILURE DOWN

Equip Machine Tools with Wagner Totally-Enclosed Motors

Shutdowns are kept down—maintenance costs are reduced when machine tools are equipped with Wagner totally-enclosed motors. They are fully protected against winding failure or bearing damage caused by steel chips, filings, dust and dirt that prevail where machine tools operate. They will give continuous service for years, even under the most adverse conditions. They require little maintenance, other than periodic inspection and lubrication.

That's why so many machine tool manufacturers have standardized on Wagner totally-enclosed motors. That's why you will find Wagner Motors a lasting investment on your machine tools.

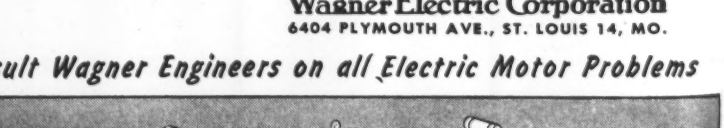
More than fifty-five years of motor building experience stands behind every motor bearing the Wagner name. Wagner maintains a nationwide sales and service organization for your convenience. Call our nearest branch office (located in 29 principal cities) for advice on your motor problems. Write for Bulletins MU-25A and MU-185. They will be sent without obligation.



Wagner Electric Corporation
6404 PLYMOUTH AVE., ST. LOUIS 14, MO.

Consult Wagner Engineers on all Electric Motor Problems

Wagner Electric Corporation EST. 1891



M48-15

• ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE PRODUCTS •

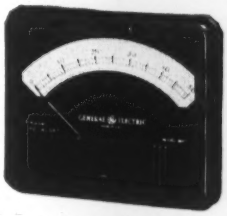
Digest

TIMELY HIGHLIGHTS ON GE PRODUCTS

TIMES "TARRY" OR "DWELL" ACCURATELY

If you are looking for a device to accurately regulate the timing of a machine motion—"dwell time" at the end of a stroke on a drill press, for example, or "tarry time" at the end of carriage travel on a grinder—you want a G-E electronic timer. Its repetitive accuracy is good—within 1/120 of a second. Each timer has a 20 to 1 range of adjustment which is stepless. Five types are available with overall timing ranges from .045 to 120 sec. All timers operate on 115- or 230-volt power. Check Bulletin GEA-2902.

SAYS "OVERLOAD!" BEFORE IT'S TOO LATE



Overloading and failure of structural parts in industrial machinery may be avoided with G-E magnetic strain-gage equipment. These gages are easily installed and economically versatile (one gage can be used repeatedly in many locations). The gage head may be mounted to give it ample support against normal vibration or shock. Amplifying equipment is not essential. Two types are available—for measuring slowly varying or rapidly varying strains. Check Bulletin GEA-3673.

SEE IT! THEN YOU'LL KNOW IT!

More and more designers are using electronic control because of its accuracy, versatility and compactness. A thorough knowledge of its theory and application will enable you to incorporate it profitably in your equipment. To help you and your organization learn quickly the fundamentals of electronics, General Electric offers a complete visual training course — twelve half-hour slide films with records, individual lesson guides keyed to the film, and a manual for the course instructor. Complete details in Bulletin GES-3303.

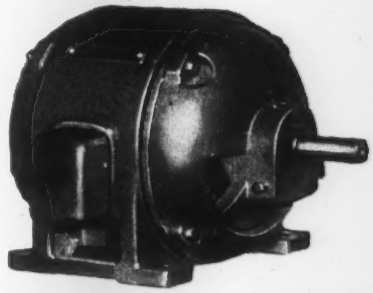
NOW READY! 3 New Thy-mo-trol Bulletins

G-E Thy-mo-trol—the drive which provides d-c performance from a-c power plus wide-range stepless speed control, controlled torque and excellent speed regulation—attracted much interest at the 1947 Machine Tool Show. We've prepared three new bulletins describing Thy-mo-trol drive. Each publication gives you all the basic facts about Thy-mo-trol drive in concise, easy-to-file form. Check Bulletin GEA-4849 (¼ to ½ hp drive), GEA-4714 (¾ to 7½ hp drive), or GEA-4847 (10 to 30 hp drive).

Now available from stock!

TRI/CLAD REG. U.S. PAT. OFF.

OPEN (DRIPPROOF) INDUCTION MOTORS



General Electric is glad to announce to machinery builders that it will now deliver Tri-Clad open (dripproof) induction motors on an off-the-shelf basis! In other words, shipment of your Tri-Clad motors will start almost as soon as your order is received. The available range of ratings is 1 to 20 hp (a few ratings in this range require a slightly longer delivery period). So, if you need induction motors now, call or write your nearest G-E sales office today. We'll be glad to tell you how soon your Tri-Clad motors will be shipped. For more information on Tri-Clad induction motors and the job they can do for you, check the coupon below.

GENERAL ELECTRIC COMPANY
Apparatus Dept., Section J 668-59, Schenectady 5, N.Y.

Please send me the following bulletins:

- ☐ GEA-4889 Electronic Amplidyne
- ☐ GEA-3992 Tri-Clad Induction Motors
- ☐ GEA-2902 Electronic Timer
- ☐ GEA-3673 Magnetic Strain-gage Equipment
- ☐ GEA-4849 Thy-mo-trol Drive (¼ to ½ hp)
- ☐ GEA-4714 Thy-mo-trol Drive (¾ to 7½ hp)
- ☐ GEA-4847 Thy-mo-trol Drive (10 to 30 hp)
- ☐ GES-3303 Industrial Electronics Training Course

CONSULT YOUR SWEET'S! You'll find "everything electric" for machinery manufacturers in the General Electric section.

NAME.....

COMPANY.....

STREET.....

CITY.....STATE.....

Topics

SHAPE CODING of controls can reduce the errors made in operating aircraft, according to an investigation made by the Army Air Forces Air Materiel Command. The study was undertaken as a basis for selection of a set of control knobs of different shapes which could be recognized through the sense of touch alone.

LABELING PROGRAM has been initiated by Automotive Air Compressor Manufacturers so that compressor units will carry a data plate stating compliance with commercial standards such as minimum overall efficiencies, maximum motor load and ASME tank.

COMPOSITE WHEEL consisting of a hub and disk of ferritic low-temperature steel and a rim of high-temperature austenitic material welded to the disk solved the problem of obtaining satisfactorily large forgings of austenitic materials for gas-turbine service.

MECHANICAL HANDS, which can perform delicate chemical experiments in dangerous radioactive areas, operate machine tools and do countless other tasks requiring great dexterity. Developed by the General Electric Co., the hands are remotely controlled. Their actions are mechanical with the exception of the wrist motion which is electrical.

MAGNESIUM TUBING, three inches in diameter, is being used for spouts for transferring gasoline into railroad cars. The tubes are long enough to reach the bottom of a tank car, minimizing splashing and the resulting fire hazard. The magnesium spouts are nonsparking.

CROSS-WIND landing wheels on a DC-3 type transport plane were successfully demonstrated recently at the Washington National Airport. Developed by Goodyear, the landing wheels are similar to those already in use on Cessna and Stinson light planes except they have a caster of 15 degrees to overcome ground looping tendencies of strong cross winds on a landing airplane. In the light planes 25 degrees of caster were needed to provide sufficient yaw angle.

FLUORESCENT PLASTICS that are self-illuminating glow under their own power and may be useful for dials, pointers and nameplates. Having the effect of built-in edge lighting, the plastic is made by impregnating Plexiglas with fluorescent dye particles. Exposure of the plastic to daylight or normal room illumination produces the lighting effect.

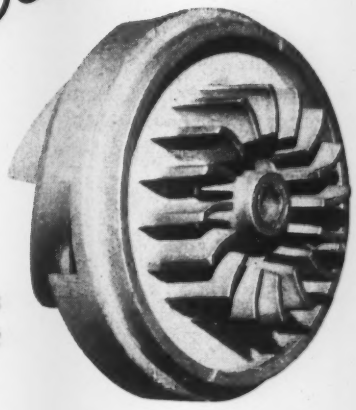
ZINC-BASE BEARINGS represent a new material that should receive engineering attention in this country. German experience has shown that these bearings have applications in electric motors, driving rods, coupling rods and transmissions. In addition they proved excellent as bearings for machine tools, street cars, locomotives, crushers, and harvesting machines, as well as wrist-pin bushings in small diesel engines.

MOBILE GAS TURBINE plants, to produce short-notice emergency electric power, are under development by Allis-Chalmers engineers. Simplicity, extremely smooth operation and no requirement for water would characterize the plants. Operating on oil, they would require only fuel line connections in addition to the electric transmission line connection.

GROWTH OF MILDEW on finished leather may be prevented with a fungicidal dressing developed at the National Bureau of Standards. Ingredients of the dressing are 20 per cent of a mixture of equal parts of neatsfoot oil and mineral oil, 2 per cent paranitrophenol, 10 per cent cyclohexanone, and 68 per cent of either perchloroethylene or Stoddard's solvent.

MACHINE DESIGN

Investment Castings



. . . their advantages and limitations plus tips on designing better parts at reasonable cost

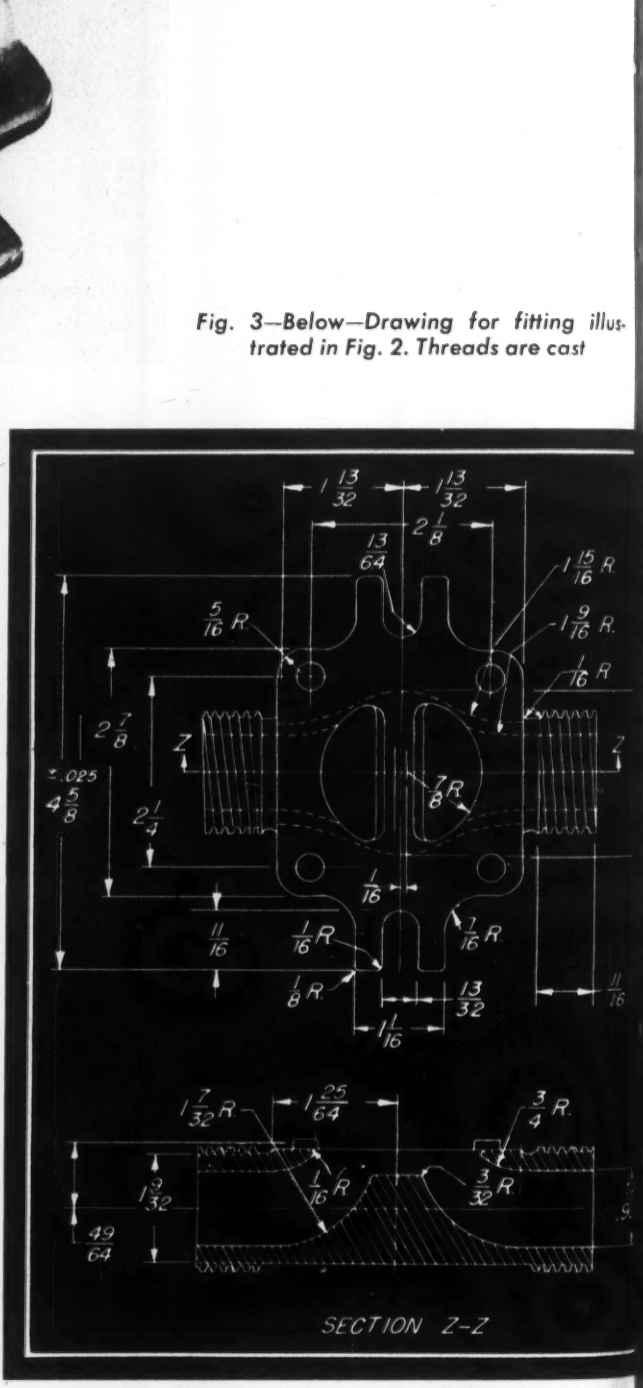
By W. O. Sweeney and H. L. Mattes
Haynes Stellite Co.
Kokomo, Ind.

FOR shapes and alloys that are difficult to machine, forge or form the lost-wax investment-casting process fills an important niche for designers. To clear up any uncertainties that may exist regarding this process, its advantages, applications and commercial limitations will be outlined. The discussion, based on experience at Haynes Stellite Co., is pertinent only to alloys with relatively high melting points. In order to develop the best possible designs for investment castings, the machine designer should have a basic conception of how cast-

Fig. 1—Above—Left and right views of a refrigerator impeller. Part is approximately 2¼ inches in diameter and is 303 stainless. Precision casting method has specific advantages for both material and shapes of this kind

Fig. 2—Left—Typical of the larger castings produced by the investment method, this part is 4⅝ inches long and 1½ inches high

Fig. 3—Below—Drawing for fitting illustrated in Fig. 2. Threads are cast



ings are produced as well as of the considerations necessary in designing parts to be investment cast.

First step in the process is the preparation of master patterns from the blueprint. These patterns are replicas of the parts desired, with an oversize allowance of approximately 1½ per cent to compensate for wax and metal shrinkage. Injection dies of a suitable soft metal are then prepared from these master patterns. There are generally from one to twenty cavities in the die, depending on the size of the part. It is desirable to get as many pieces into the die as practical because, with more cavities, each wax injection produces more wax patterns. For simple shapes, the cavities can be machined in steel dies. For trial runs, wax patterns can be machined, but this is neither economical nor satisfactory for production.

Completing the Wax Patterns

After the wax is injected into the die, the wax patterns are removed and inspected. These patterns are assembled by "wax welding" to gates and risers and then dipped in a very fine silica suspended in a suitable medium. Somewhat coarser grains are screened or "stuccoed" to the dip coating. Presence of this fine material next to the wax is partly responsible for the smooth finish on precision castings.

After being cured the wax assembly is placed in a flask and a chemically hardening investment material is poured into the mold. After being filled with investment, the mold is placed on a vibrator to pack the investment tightly around the pattern and to make sure that all entrapped air is removed. When the investment has gelled and aged for several hours the molds are placed in a continuous furnace to melt out the wax. Later, any residue is burned out as the mold progresses into the hotter zones where the molds are heated to temperatures of 1300 to 1900 F, depending on the part to be cast.

Accurately weighed charges of the desired alloy are meanwhile being melted in small indirect-arc furnaces. After the temperature of the metal in the furnace is checked with an optical pyrometer, the heated mold is placed directly over the pouring spout of the furnace. Next the mold is clamped onto the furnace and the metal is poured by inverting the

entire furnace 180 degrees. Hot molds plus air pressure, which is introduced at the time the furnace is inverted, make it possible to cast extremely thin edges and also help to produce sound and dense castings. Correct mold and pouring temperatures control grain size and assure good metallurgical characteristics.

The mold is allowed to cool slowly and, after about four hours, the entire casting assembly is knocked from the mold. Gates and risers are cut off and the castings are shot blasted, rough inspected and any with obvious defects are rejected. The grinding department smooths the gate areas and removes any surface irregularities. Finally, the castings are sand blasted and inspected by one or more of the following methods, depending on service requirements of the casting: Visual and dimensional check, Zyglo inspection (a fluorescent penetrative oil test that reveals cracks or other surface imperfections in nonmagnetic materials) or x-ray test.

As an example of the types of parts for which this method of casting has specific advantages, *Fig.* 1 shows a Type 303 stainless steel impeller for refrigerator equipment. The intricate contours on this part would be more costly to produce by other methods.

Size of a casting is limited by two factors, either the die or the investment flask. Current restrictions for a cast soft-metal die are approximately 10 x 10 x 5 inches. Larger dies can be made by machining the cavity from aluminum or other suitable light alloys. In the case of machined dies, the size will be limited by the weight of the investment mold that can be handled or the size of the flask that can be passed through the mold heating ovens. *Figs.* 2 and 3 show a part which is considered typical of the larger castings. The largest part that we have produced in quantity is a generator mounting bracket which is approximately 7 inches OD by 3 inches thick and is cast two to the mold.

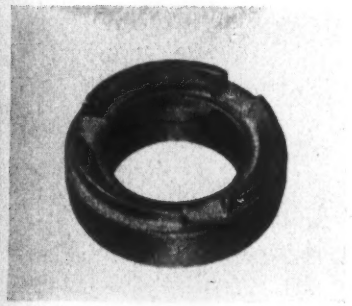


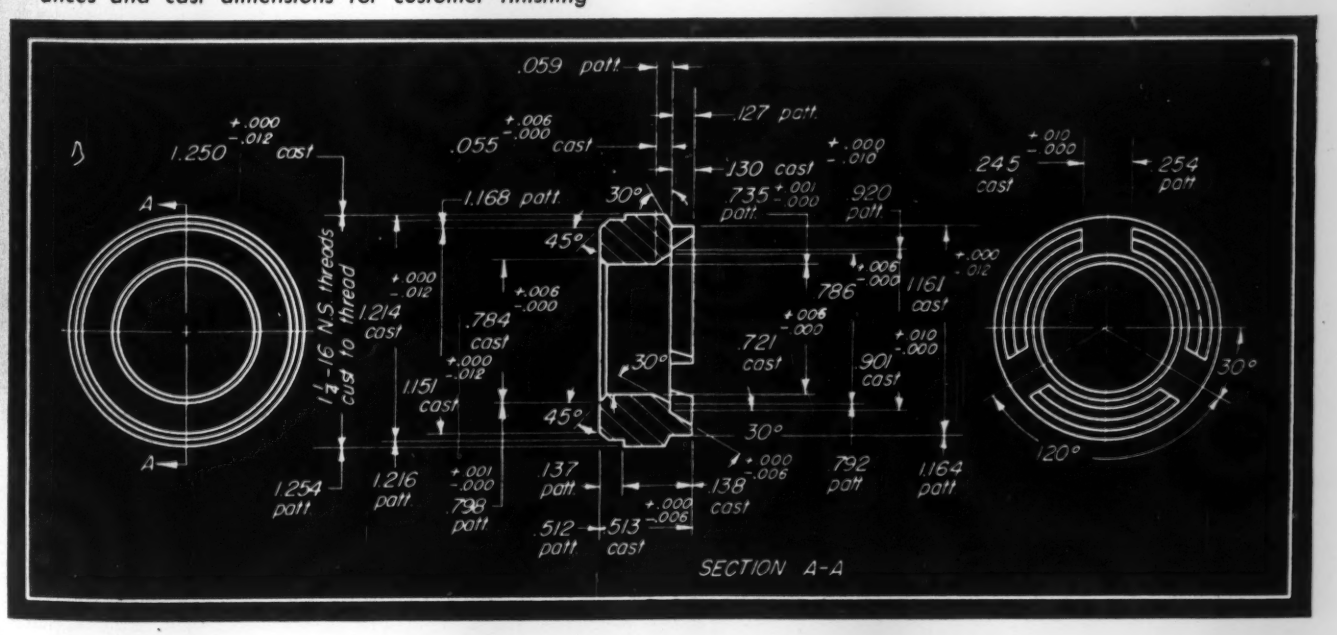
Fig. 4 — Left — Average small part, approximately 1¼ by ½-inch. Short relatively large holes, as in this part, are easy to cast

Factors Affecting Weight Limits

WEIGHT: There is no minimum limitation on weight, provided the casting meets the minimum requirements of thickness and hole diameters. The smallest part that we have made in any quantity weighs approximately 0.002-pound. The maximum weight of a part is dependent upon the method of casting. For pressure casting in which air pressure is applied behind the flow of molten metal in an indirect-arc tilting furnace, the maximum weight is currently approximately 3½ pounds. *Figs.* 4 and 5 picture an average small part. *Figs.* 6 and 7 show a part that is currently considered an average heavy casting.

HOLES: Holes can be readily cast. However, the decision to cast holes should be given the following considerations: Size of the hole, its location, the alloy, and the tolerance on the hole and on its location. Also, if the hole is to be used as a bearing surface or as a metering device, it will have to be finished, as the cast surface will not be suitable. If the hole is used for a bolt, loose fit, oil passage, or other purposes where close tolerances are not necessary, then the as-cast hole will be good enough. *Figs.* 8 and 9 illustrate a small hole surrounded by a large mass of metal, which presents casting prob-

Fig. 5—Below—Drawing for part in Fig. 4, showing tolerances and cast dimensions for customer finishing



lems. *Figs.* 4 and 5 illustrate a large, simple hole which presents no problems.

Generally speaking, the smaller the hole and the more metal there is around it, the harder it is to cast. For example, a ¼-inch hole, approximately ½-inch deep would be easy to obtain but, if required for a depth of 6 inches, it would be a problem. However, such a hole could be made by the use of special prefabricated ceramic cores. If the hole is round, the use of this prefabricated material is practicable, but when special shapes are involved, it becomes expensive. To cast a blind hole is always much more difficult than a through hole.

Soluble cores can be used for holes of intricate shape where a retractable core cannot be pulled from the wax pattern. This method of obtaining a hole is used only as a last resort because it is expensive and close tolerances cannot be held easily.

WALLS: The wall thickness of a part will, in general, depend upon the adjoining sections and the areas of the wall, *Figs.* 10 and 11. Normally, the minimum wall thickness practicable for production is approximately 0.050-inch for a uniform small section. Thickness may be as small as 0.030-inch provided there is a sufficient taper to permit accurate feeding.

Edge Thickness Limits

EDGES: The thickness is generally the limiting factor in casting an edge. The minimum practical edge thickness is currently considered to be 0.012 to 0.015-inch provided there is a gradual tapering, rather than an abrupt sectional change. While thinner sections can be cast the recovery is lower, increasing the cost and involving handling problems in the foundry, in shipment and in the consumer's plant. On serrations where there is a large angle, a radius of 0.005-inch is possible, particularly if there is a fine pitch. The problem present in casting serrations is the difficulty of cleaning out small globules of metal or preventing small air bubbles at these points on the wax pattern, resulting from trapped air present either in the investment or in the wax pattern.

THREADS: Unless the alloy, size, or form of the threads is unusual, it is generally more economical to machine, tap, or grind threads. External threads may have a part line, but internal threads do not. A thread is analogous to a serration because of the problem of globules of metal in the threads. If the length of the thread to be cast is greater than ½-inch, the master pattern for the part must have the pitch compensated for shrinkage allowance. Even if

Fig. 6—Typical heavy casting. Dimensions are 4⅝ by 2¼ inches

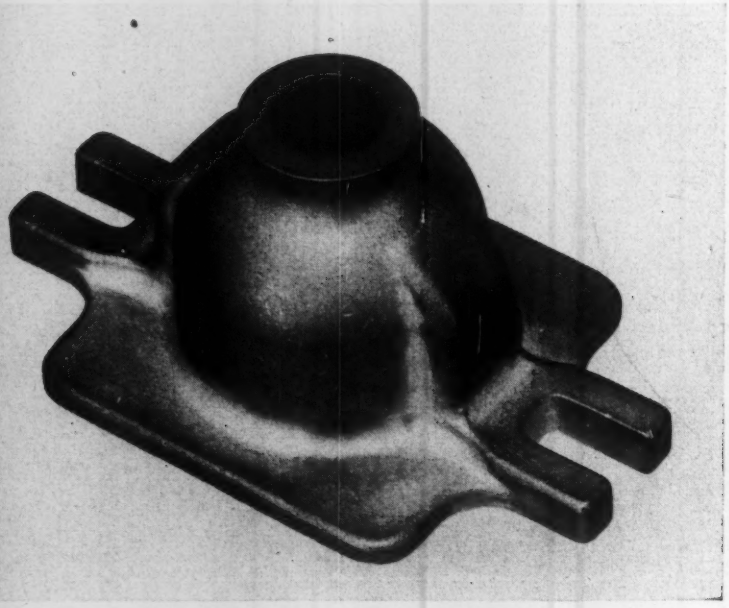
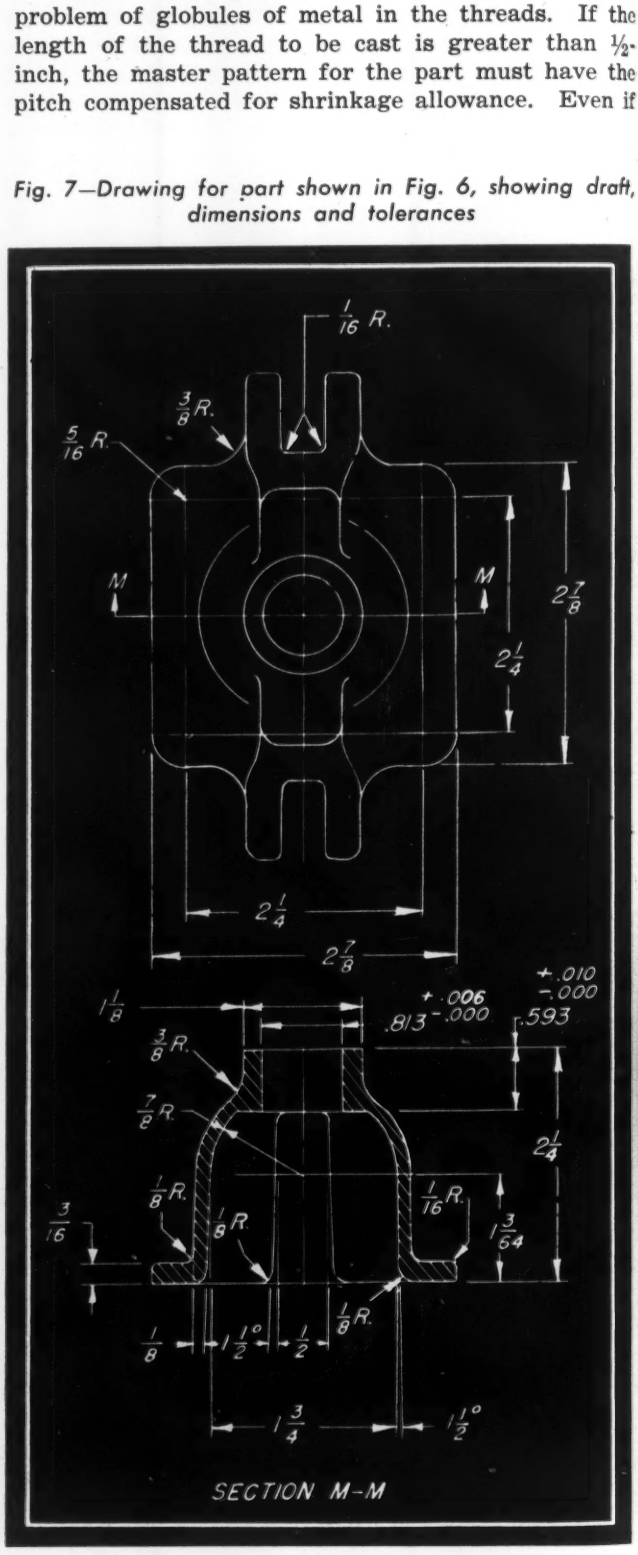


Fig. 7—Drawing for part shown in Fig. 6, showing draft, dimensions and tolerances



the thread is chased, a Class 1 fit is the best that can be obtained with a cast thread.

SURFACES: The smooth surface of investment castings is due in part to the type of material used in the mold. A fact that has not always been made apparent is that minor surface flaws are removed by hand grinding. On any areas which cannot be readily ground, the casting will be rougher than the standard accepted precision casting finish. Pits and bumps are more likely to appear on the surface of a piece when the surface is large and flat.

FILLETS: Frequently advantageous from a stress standpoint, fillets are difficult to make by conventional means of manufacture, because in milling or other machining operations a square corner is normally obtained. Generous fillets are definitely helpful in the precision casting process, and with many parts are almost mandatory. In addition, fillets are more readily cleaned by hand grinding than square corners. At least a 1/32-inch fillet is desired, and generally a 1/16 to 1/8-inch fillet is not too much.

CHANGES IN SECTION: Abrupt changes of section in a precision investment casting are to be avoided just as in the conventional type of casting. Thin sections adjoining heavy sections are difficult to feed, and consequently are subject to considerably more warpage and distortion. Shown in *Fig.* 12 is an example of a part which was redesigned to eliminate abrupt changes in section. The part was made of Haynes Stellite Alloy No. 6. The ribbed section was originally solid but, by redesigning the part, it was made practical for precision casting and the price was reduced appreciably.

UNDERCUTS: Undercuts or negative angles are undesirable, but they can be made by using cores in the die. This procedure, however, increases the cost and makes it more difficult to avoid the distortion that results from the handling of the wax pattern. Whether or not the part has an undercut is dependent upon how the die must be parted. In general, for ease of production and lower cost, it is desirable to have a simple two-piece die which does not involve complicated cores and additional handling.

DRAFT: A point that the designer should take into account when considering the precision casting of a part is that its pattern must be removed from a die without distortion. This requires draft on those surfaces perpendicular to the parting line of the die. It is possible to have the part in a die in more than one place and so a designer should indicate which surfaces may have draft and which surfaces should not. In other words, the desired draft allowance should be included in the design of the part so that it does not interfere with its function. The draft allowance should be as generous as possible with a minimum of ½-degree per face.

GATING AREAS: Unfortunately, a casting must be gated in order to feed metal into the part. These gates must be removed. Wherever possible the gates should be located in an area which will require finish grinding or machining, or which will not interfere with the function of the part if it does not have subsequent machining operations performed on it. The normal practice is to remove the evidence of the gates by hand grinding and obviously this is not a precision operation. Frequently it is necessary to gate into one or more places on a casting, and it is not always possible to predict in advance where the gate should be located for obtaining the best casting results. It is highly desirable that the designer indicate those surfaces where gates are the least desirable.

PART LINES: As in the case of gates and drafts, the casting will have a part line, and the designer should indicate the most suitable areas. The designer can do more toward controlling location of the part line than he can toward controlling gating,

Fig. 9—Pattern and cast tolerances on critical dimensions are indicated on this drawing for the part shown in Fig. 8

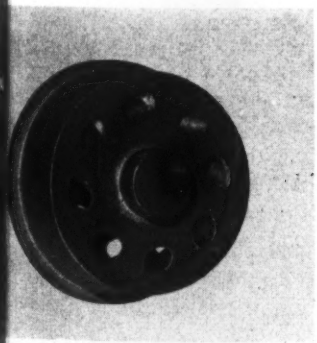


Fig. 8—Above—Small holes surrounded by large mass of metal are difficult to cast compared to the type of hole illustrated in Fig. 4

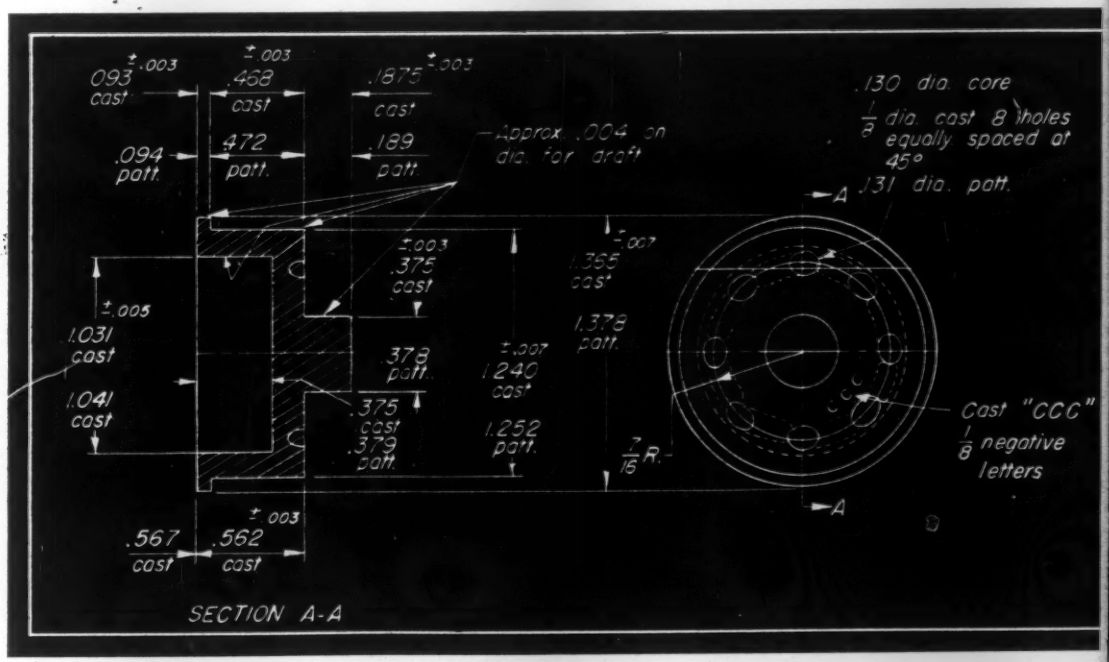
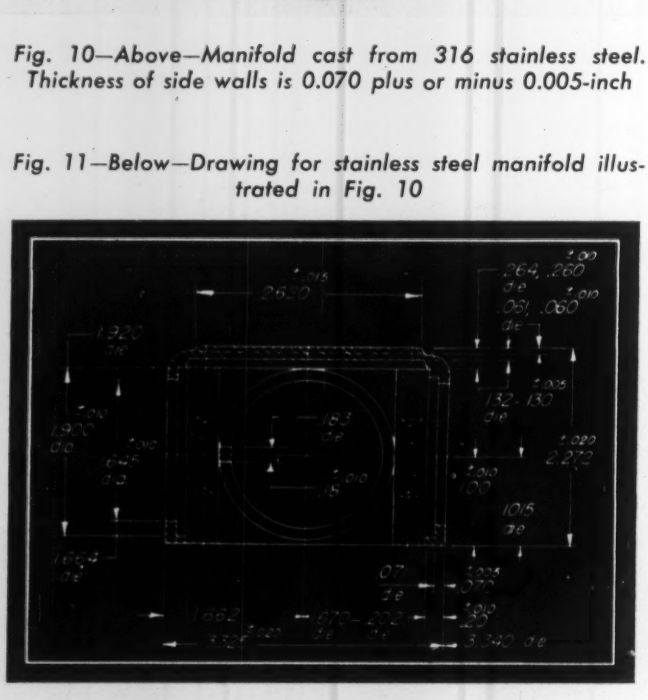


Fig. 10—Above—Manifold cast from 316 stainless steel. Thickness of side walls is 0.070 plus or minus 0.005-inch

Fig. 11—Below—Drawing for stainless steel manifold illustrated in Fig. 10



because location of the part line is basically dependent upon being able to make a simple two-piece die, whereas gating is oftentimes determined by trial and error, and foundry experience must be the determining factor.

TOLERANCES: Draft, gates, and part-line considerations all have a bearing on the tolerances that are to be held on a casting. Generally wider tolerances are necessary for those dimensions which are affected by these factors. The tolerances which currently are commercially practicable are plus or minus 0.005-inch per inch of dimension, with a minimum tolerance of plus or minus 0.003-inch. However, any one or the combined influences of part lines, gating or draft may make these tolerances practically impossible to hold. Where close tolerances are not required on certain dimensions, the designer should allow as much flexibility as possible. This not only makes for a lower cost per piece but also helps the manufacturer to work out his technique to get the close tolerances that are necessary. Generally, the tolerances which are allowed on master patterns are one-third of those allowed on the casting.

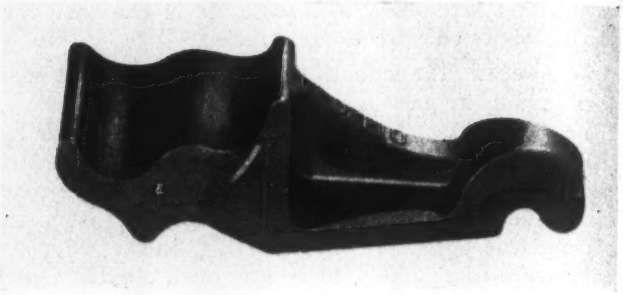


Fig. 12—To avoid warpage and distortion this part was redesigned to have more uniform sections. Originally the ribbed section was solid

One of the best adaptations of precision casting is to obtain intricate shapes and contours cast to size with an allowance of finishing stock on bearing surfaces, *Fig.* 13, threaded areas, and other close tolerance dimensions, which can be finished economically by secondary operations such as grinding, machining, or threading.

WARPAGE: On certain sizes, shapes and alloys, warpage must also be considered in designing a part and in making allowances for finishing it. Generally, the longer and thinner the sections and the softer the alloys, the more chance there is for warpage. While softer alloys are more subject to distortion, they are straightened more readily than sections made of hard or brittle materials. In general, the warpage problem is somewhat the same as for the same shape and alloys when produced by other means of manufacture.

Causes of Distortion on Round Parts

OUT-OF-ROUNDNESS: The principal factors influencing out-of-roundness in a given diameter are part line, draft and location of gates. Out-of-roundness often results when it is necessary to gate into the diameter and also because the gate tends to distort the part by pulling unequally in one or more directions.

MATERIALS: Clean, sound, dense metal can be obtained by precision casting. This process is more economical, generally, for higher priced alloys than for the lower priced materials. The process is particularly suitable to alloys which are difficult to machine, grind, or forge.

INTEGRAL CASTING: Oftentimes it is possible to combine two or more parts into one integral casting, thus eliminating assembly costs and frequently improving design. To date, not much consideration has been given to this design feature, but there is a large field to be opened by combining several parts into an integral casting, *Figs.* 14 and 15. Thus, two wax patterns are sometimes joined together and a

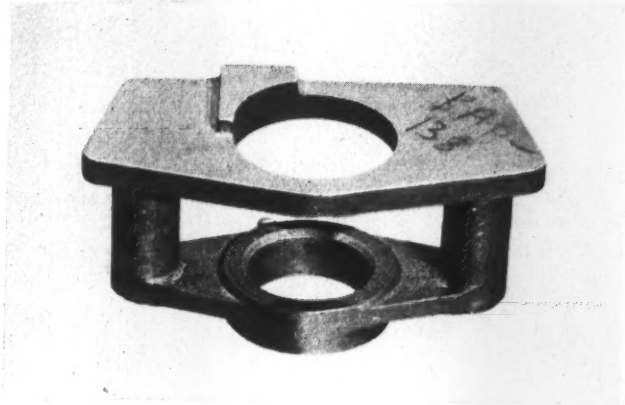


Fig. 13—Fitting cast from 410 stainless steel is approximately 2½ by 1¼ inches

single casting results.

INSPECTION: While castings can be made x-ray sound, this often requires complicated gating procedures. Frequently economies can be effected by the use of simpler foundry practice, provided minor internal porosity is not objectionable. For highly stressed parts, internal soundness is a prime requisite but, for many types of parts, minor internal shrinkage is not detrimental to the performance of the part. For some applications, pits and other blemishes are intolerable, but for many they are acceptable. Moreover, some parts require only one or more surfaces to be free from imperfections. Since the cost of the part is directly related to the number of parts rejected, inspection standards required for a particular part should be clearly stated by the designer.

The following points should be borne in mind when designing a part to be made by the precision investment casting process:

1. Fillets, intricate contours, etc., that ordinarily are prohibitive in cost by other methods of manufacture may be employed freely
2. Tolerances that are placed on a drawing should be only those which are essential. The addition of tolerances which are not required serves only to make the part more difficult to cast and unreasonably expensive
3. The part should be designed so that part lines, gates, and draft allowances do not interfere with any close tolerances that may be required for the use of the part
4. Inspection requirements for surface finish and metallurgical soundness should be specified only where required
5. This process, like other processes, has its limitations. A part being considered for investment casting should be designed to take full advantage of the good points and overcome, where necessary, the limitations which might involve a secondary operation
6. Heavy alloys such as Haynes Stellite alloy, Hastelloy alloy and stainless steels, which are in some instances impossible and oftentimes difficult to machine, can be produced in shapes and forms with reasonably close tolerances

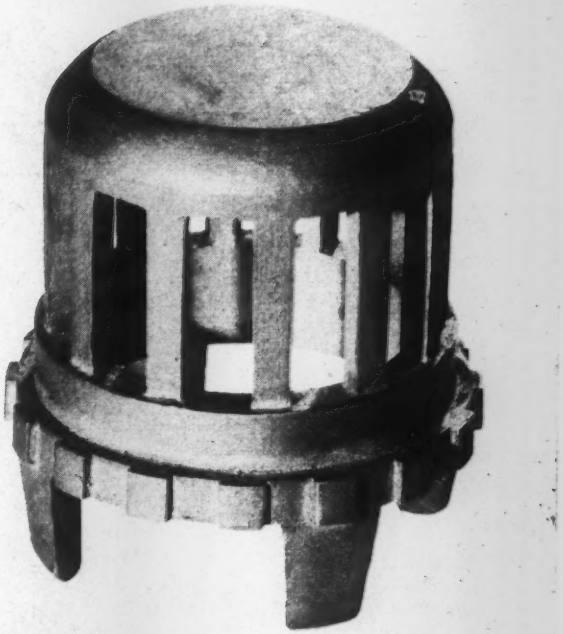
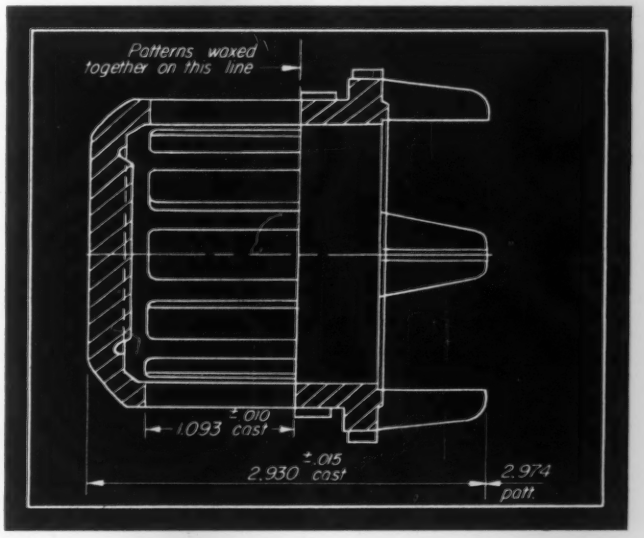


Fig. 14—Above—Valve cage of 316 stainless steel. Two wax patterns are joined to produce an integral casting

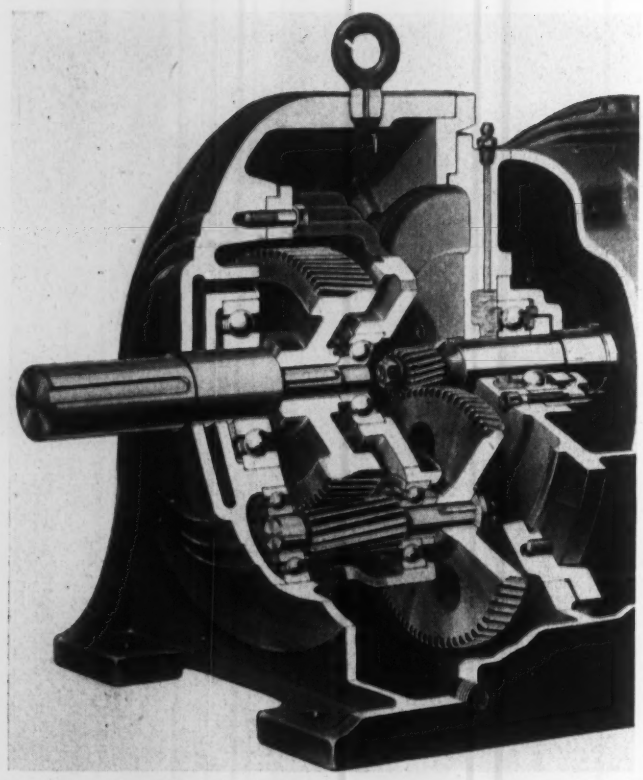
Fig. 15—Below—Drawing for valve cage in Fig. 14, showing how two wax patterns may be joined to make an integral casting



7. Best results are obtained by close co-operation between the designer and the producer of precision castings.

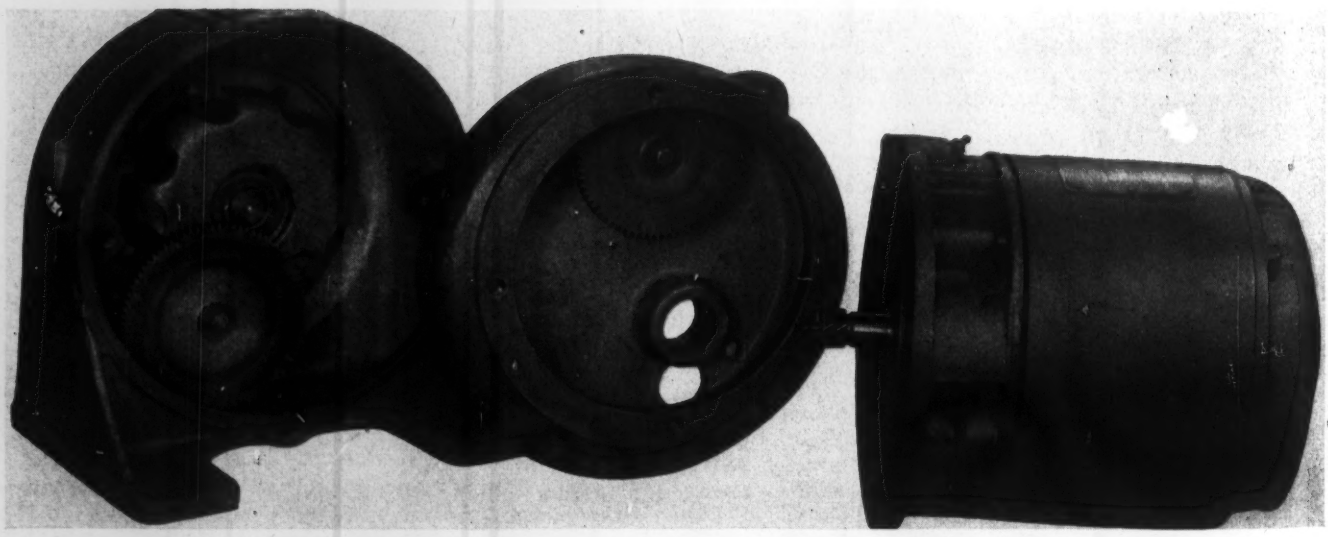
The precision-casting process has a definite and important place in industry. It does not compete on a price basis with low-cost means of mass production (such as screw machine operations, stamping, and die casting), but it does fill a specific need where there are shapes or alloys that are difficult to machine, forge, or form.

Scanning THE FIELD for Ideas



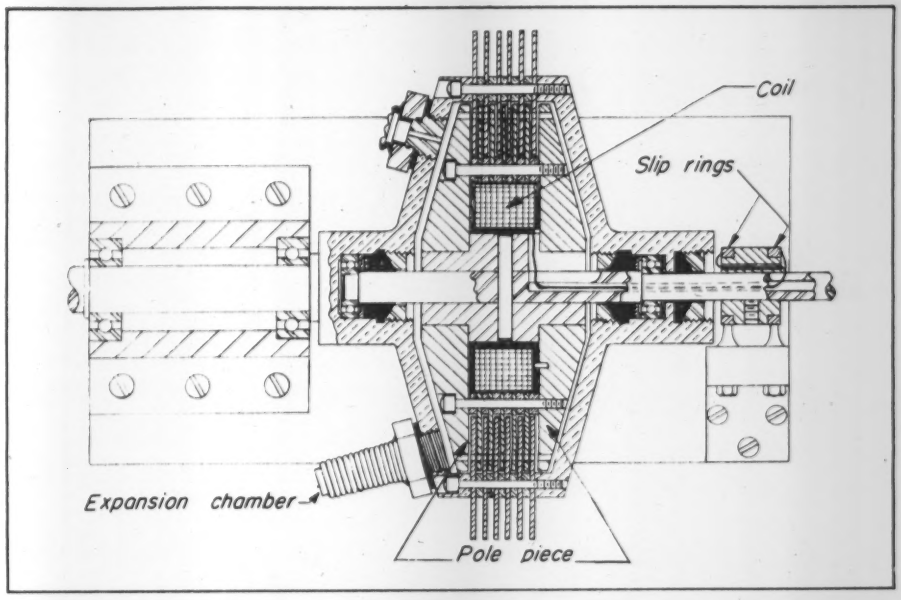
STANDARDIZED and simplified design of the gearmotor at left provides for converting this double-reduction unit into a three-stage gearmotor. A single-stage reduction assembly bracket is mounted between the motor and double-reduction gearing, as indicated in the disassembled view below, to make the three-stage unit from standard assemblies. Developed jointly by The Reliance Electric & Engineering Co. and the Philadelphia Gear Works, design of this triple-reduction unit allows a triangular grouping of gear loads that results in the cancellation of loads and reduces the resultant strains.

Considerable degree of standardization is attained in the gears. Since the output speeds are based on a geometric progression, the gear ratios fall in the same pattern. Only two ratios are required in the final reduction. Combined with the five ratios employed in single-stage units, this simplification has reduced the number of gears from 324 for a previous design to 42. The gears, cut from steel forgings, are hardened to a predetermined depth with practically no change in the structure of the untreated portion of the forging, the core and gear

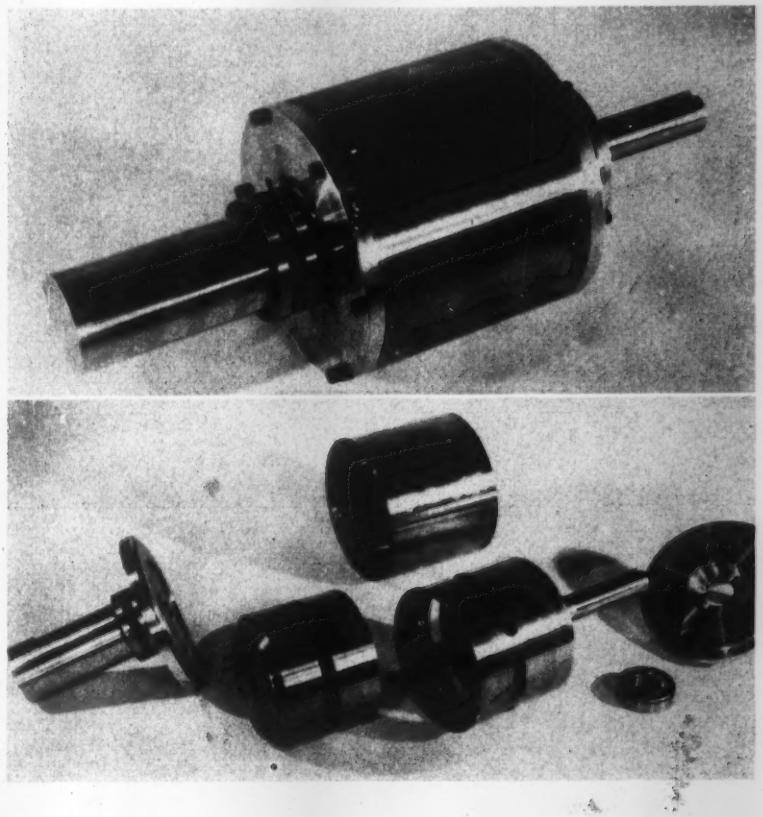


hub remaining unaffected. Teeth are helical of full involute form and shaved before hardening to give correct form, accurate angle and smooth finish for quiet operation.

By performing all machining on the multistage housings from one end of the housing, manufacturing tolerances are held closely.



Electromagnetic clutch, right, employing finely divided magnetic particles suspended in oil between the driving and driven disks of the clutch, is controlled by a magnetic field between the disks. Characterized by high efficiency, smooth operation, long life, and simplicity of construction the clutch is particularly suitable for use in servomechanisms and automatic machinery where ease of control and constancy of characteristics are important.



Developed by Jacob Rabinow, chief of ordnance mechanics section of the National Bureau of Standards, the clutch operates on the following principle: When the space between two parallel magnetic surfaces is filled with finely divided magnetic particles with a magnetic field between the two plates, the magnetic particles bind the plates against movement parallel to their surfaces. These particles may be finely divided iron mixed with oil to prevent packing and to afford smooth operation. When acted on by the magnetic field these particles are mutually attracted and the mixture seemingly solidifies between the clutch plates.

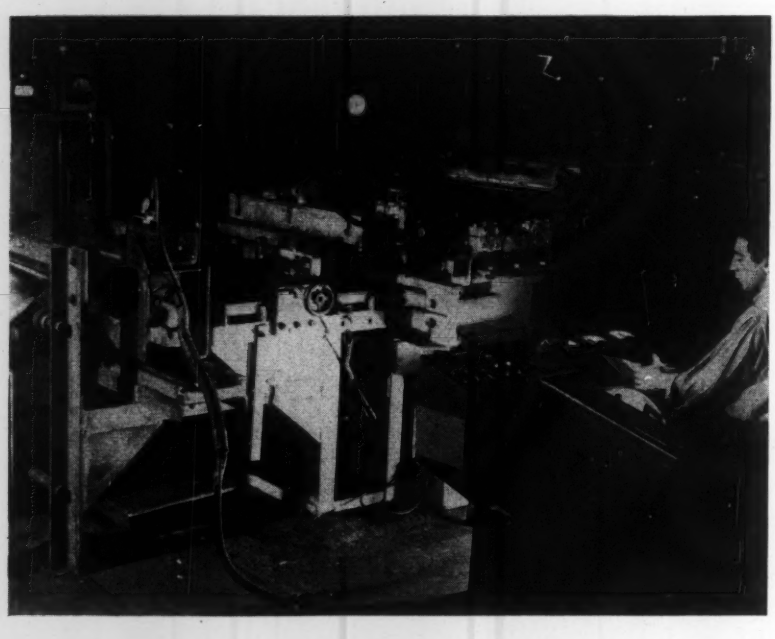
Requiring little electrical power, control is smooth from minimum transmitted torque, determined by the viscous drag of the oil, to maximum, controlled by the magnetic saturation of the iron. Unlike other types of electromagnetic clutches, torque is proportional to the control current over a wide range. This feature makes the clutch particularly suitable for servomechanisms where linearity and good control down to zero current are of primary importance.

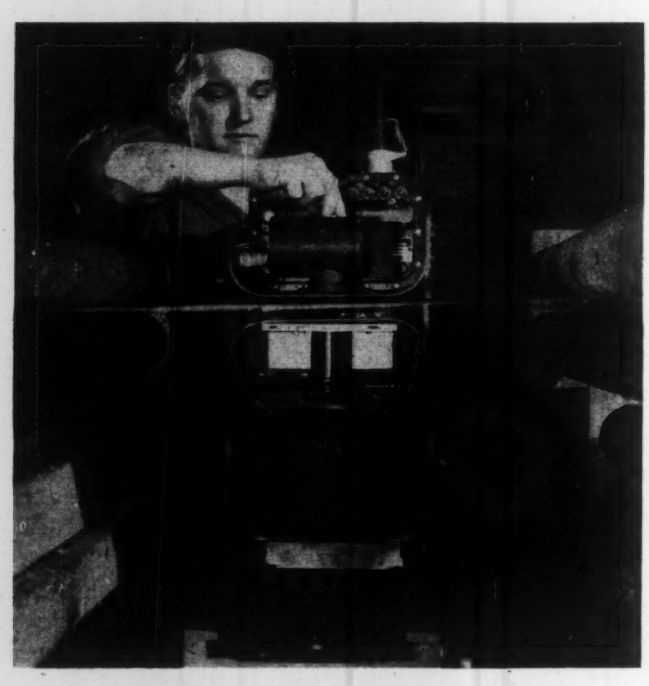
Static friction in the clutch does not differ appreciably from the value of kinetic friction, therefore no discontinuities in torque exist at the instant of initiation of slip. This precludes chattering and assures smooth action. As slipping occurs only between the iron particles and between them and the smooth faces of the clutch, wear is negligible. In addition, if any of the clutch surfaces are worn off, the iron dust thus generated simply adds to the iron powder in the oil mixture.

Many clutch designs are possible including the disk type illustrated in cross section as well as cylindrical units like the type illustrated in the photograph above. This clutch, 6 inches in diameter and 6½ inches long, will transmit 40 hp at 3000 rpm. Consideration of the design of magnetic circuits employed in these clutches leads to the following conclusions: Gaps in parallel or single gaps of large area entail large amounts of iron and

small copper losses. Gaps in series reduce the amount of iron but require more excitation. Multiple-plate clutches can be designed so that the sets of plates are either in series or in parallel.

In one clutch design it was found that a mixture of oil and carbonyl E iron, composed of particles with an average size of 8 microns, gave the best results. This, however, may not be true with other designs. When iron powder is used without the oil, tranmitted torques are similar but operation is erratic due to eccentricity or plate misalignment. The type of oil employed has little effect on performance, and for extreme temperature conditions silicone liquids have been used with excellent results.

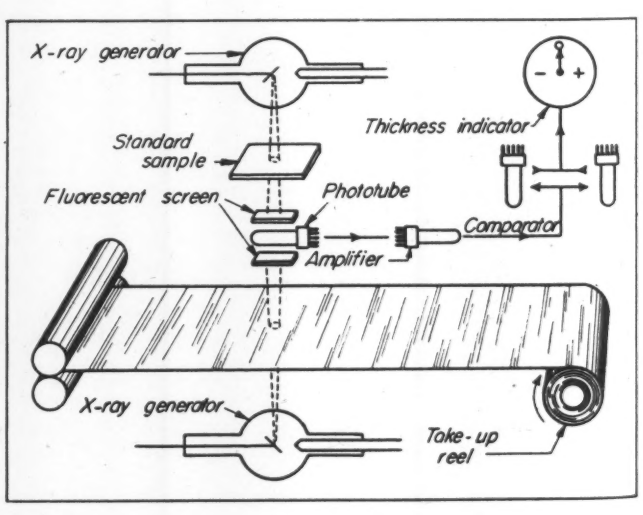


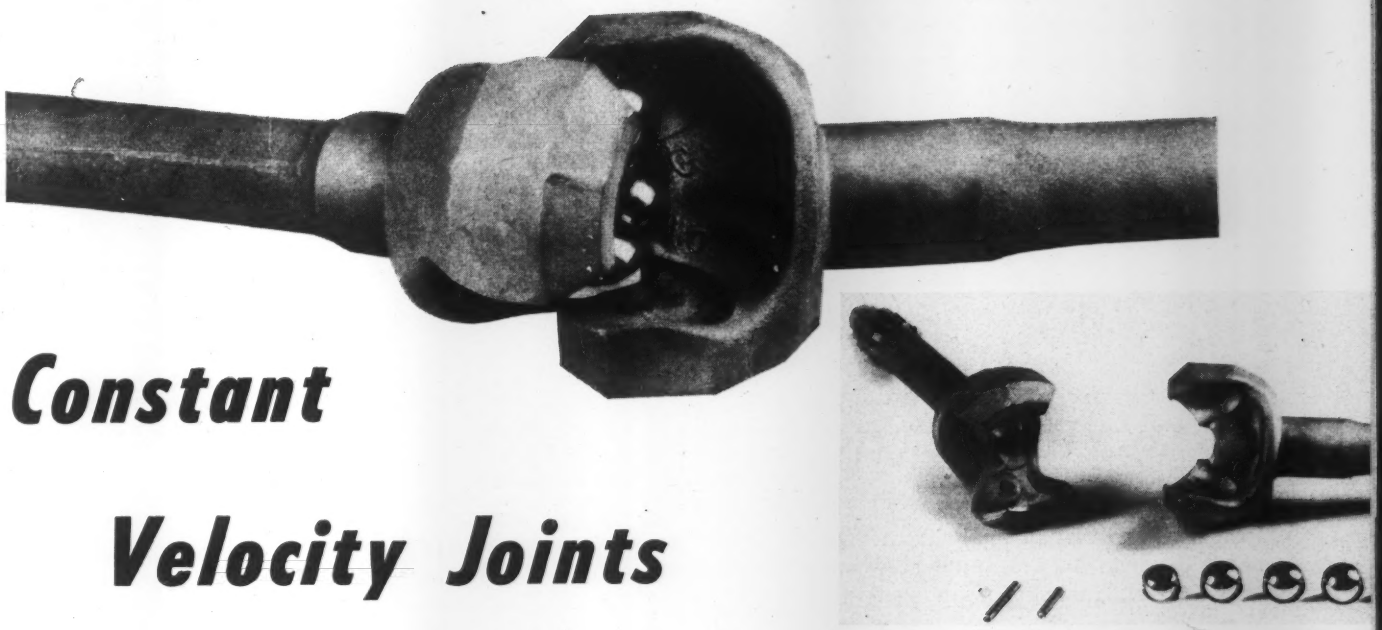


Thickness gaging with x-rays has the advantages of no contact with the material being gaged, access to areas never before gaged, and high sensitivity and accuracy. As a quality control instrument the x-ray gage, left below, is expected to be used for thickness control of hot metal and glass sheet, aluminum foil, plastics, paper, and other sheet and strip stock.

Employing two x-ray sources at right angles with one photomultiplier-fluorescent screen pickup unit at the apex, the gage compares the controlled material to a correct sample. The two sources emit x-rays 180 degrees out of phase. Arrangement of the components is shown in the schematic sketch, below. Positive and negative readings showing the thickness differential above or below the standard sample are indicated on an instrument within view of the operator. The gage automatically rejects off-gage material in flying shear applications or controls the screw-downs to maintain uniform thickness coming from the mill.

Shown at left is a Westinghouse x-ray thickness gage set up on a classifier and shear line in the tin plate mill at the Jones & Laughlin Steel Corp. plant at Aliquippa, Pa. Attached to the left-hand side of the operator's control desk is the remote control unit for the gage. The cable in the foreground leads to the gage on the strip and the smaller instrument in the left background is the thickness indicator. The indicator needle on the gage instrument will react to a variation of 0.0001-inch in a 0.1-inch thick sheet. Unaffected by fluttering of the sheet, the instrument also is not influenced by surface coatings such as lacquer or by atmospheres heavy with palm oil, steam and water. Normally it is mounted on a slide so that it can be removed.





Constant Velocity Joints

. . . how and why they operate as they do

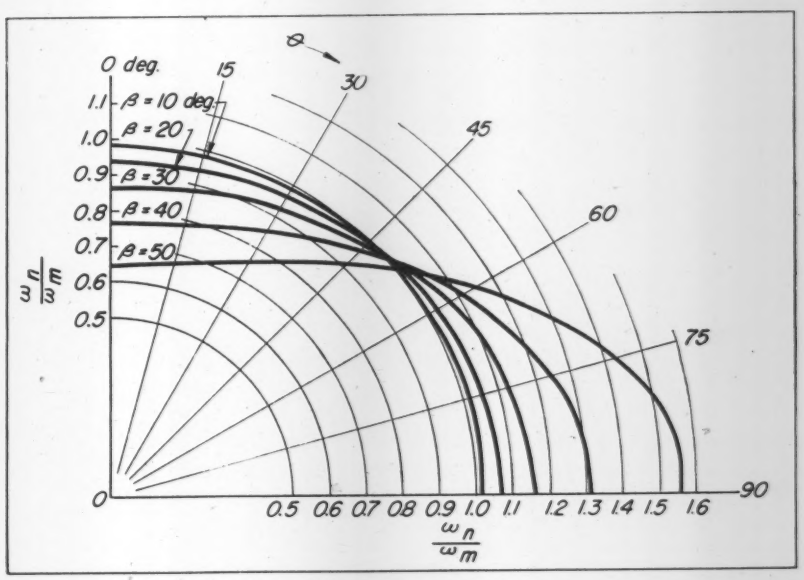
By H. H. Mabie
Assistant Professor of Machine Design
Cornell University
Ithaca, N. Y.

OBJECTION to the speed variations that occur in conventional universal joints has led to the development of "constant velocity ratio" types well adapted for use in high-speed machinery. Although much has been written about the manufacture and operation of such joints, one of which is illustrated in *Fig.* 1, little has been published concerning the proof of the ability of these joints to transmit a constant velocity ratio. This article will deal briefly with a geometric proof to show the requirements for a constant-velocity joint and with a demonstration of how each of the three available types meets these specifications.

Before considering these joints, it is pertinent to review briefly the Hooke's coupling, or Cardan joint as it is sometimes called, which furnishes one method of coupling two shafts whose axes intersect. It is well known that while both shafts must complete a revolution in the same length of time, the angular velocity ratio of the two shafts is not constant during each revolution. The maximum variation in the angular ve-

Fig. 1—Top—Bendix-Weiss constant-velocity joint shown both assembled and disassembled

Fig. 2—Below—Polar diagram showing how ratio of output to input rpm varies during rotation of a Hooke's joint



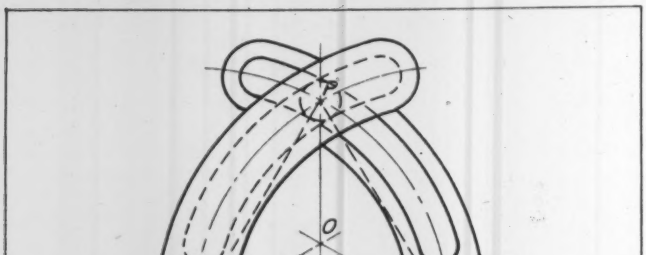


Fig. 3—Elementary ball type joint illustrating the principle behind the constant-velocity joint

locity of the driven shaft from that of the driving shaft depends on the angle between the axes of the two shafts. In *Fig.* 2 is shown a polar diagram of this variation, for a quarter revolution of the driving shaft, which is given by the equation[1]

$$\frac{\omega_n}{\omega_m} = \frac{\cos\beta}{1 - \sin^2\beta\sin^2\theta}$$

in which ω_n represents the angular velocity of the driven shaft, ω_m that of the driving shaft, θ the angle through which the driving shaft has turned and β the angle between the two shafts. From this diagram it can easily be seen that this variation in velocity ratio is more pronounced the greater the angle between the shafts becomes.

This type of joint has been in use for many years, and still finds many applications in spite of this inherent disadvantage. With the development of machinery operating at higher speeds, however, the use of such a joint means high acceleration forces corresponding to the speed variation. It is possible to eliminate this difference in velocity between the driver and the follower by the use of two couplings and an intermediate shaft. The driver and the driven shafts must make equal angles with the intermediate shaft, and the position of the forks on the intermediate shaft must be such that when one fork lies in the plane of the drive shaft and the intermediate shaft, the other fork will lie in the plane of the intermediate shaft and the driven shaft. There are many applications where it is exceedingly difficult because of space limitations to fulfill these specified requirements for the use of two Hooke's couplings.

For many years engineers have been considering the development of a single universal joint capable of transmitting a constant velocity ratio. Several joints which were variations of the Hooke's principle were proposed, one as early as 1870, with the intermediate shaft reduced to "zero" length. In this manner it was possible to reduce the amount of space required to accommodate two joints and an intermediate shaft. As far as is known, however, joints of this design have never been used to any extent commercially.

Development of the front wheel drive for automotive vehicles required a universal joint which was capable of transmitting a constant angular velocity ratio. This need was met by the introduction of the Weiss and the Rzeppa joints in this country, and by the Tracta joint in France. The Weiss joint was first patented in 1925, the Rzeppa in 1928, and the Tracta in 1933. Although the manufacture of front-wheel-drive passenger cars has been discontinued in the United States, these units are now used extensively in military vehicles, road construction equipment trucks, and other types of heavy vehicles.

Operation of the Bendix-Weiss, Rzeppa, and Tracta joints is based on a principle different from that of the Hooke's coupling as will be shown. First, a theoretical joint will be considered in order to investigate this principle. Then it will be shown how these joints compare with the theoretical joint.

In *Fig.* 3 is shown a theoretical joint[2] with two shafts *A* and *B* whose center lines intersect at *O*. The shafts are provided with grooved arms. These grooves accommodate a ball with center *P* which must always lie at their intersection. By construction the grooves are made symmetrical with respect to each other about the line *OP*. The curvature of the grooves has no effect on the velocity ratio. They could be of any shape, such as straight or concentric about the shaft intersection *O*, provided that the condition of symmetry is met. The centerline of the left groove intersects the shaft axis at *C* while the right center line cuts the axis at *D*. Point *P* is connected by straight lines to points *C* and *D*. From the construction, the triangles *COP* and *DOP* are congruent; therefore *CO* = *DO*, angle *PCO* = angle *PDO*, and a plane passed through the line *PO* perpendicular to the plane of the shafts bisects the angle between the shafts. It will be proved next that if shaft *A* is rotated, the angle turned through by shaft *B* will be equal to that turned through by shaft *A*. Thus the angular velocity ratio of driver to follower will be constant.

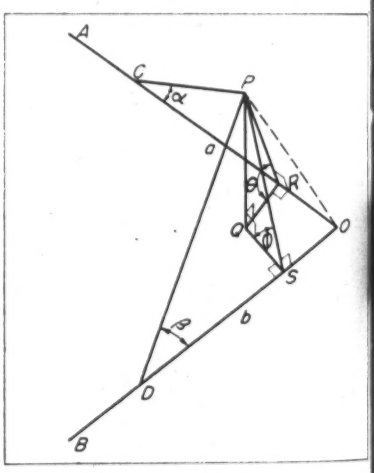


Fig. 4—Schematic diagram showing joint of Fig. 3 after shafts have turned through angles θ and φ respectively

[1] References are tabulated at end of article.

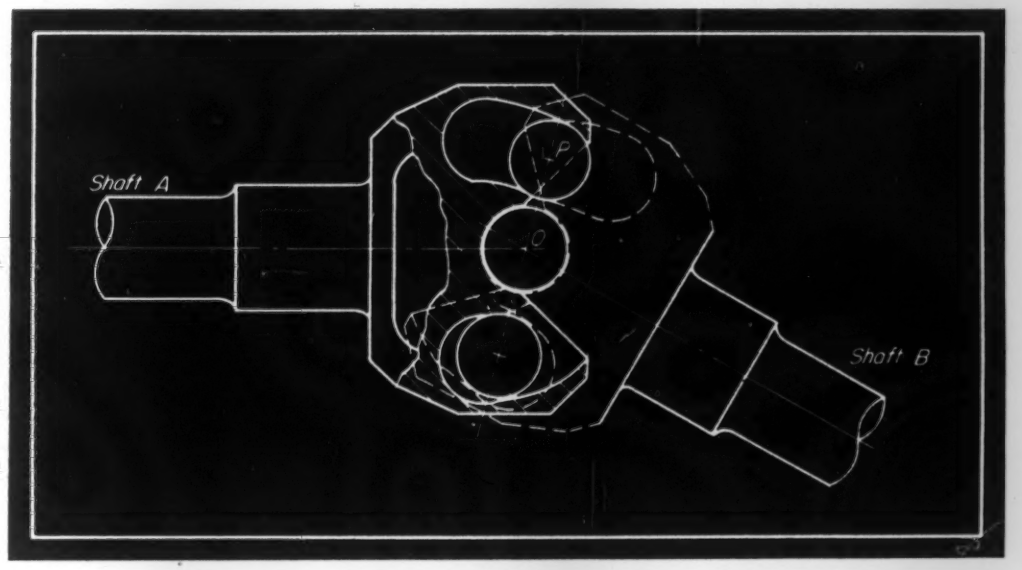


Fig. 5 — Cross section through Bendix-Weiss joint with right-hand yoke rotated 90 deg to show more clearly the groove relationships

In *Fig.* 4 the joint of *Fig.* 3 is shown diagrammatically[2], the shaft *A* having turned through some angle θ about its axis, causing the shaft *B* to turn through an angle ϕ. Let the distances *OC* and *OD* be signified by *a* and *b* respectively, and let the angle *PCO* and angle *PDO* be α and β respectively. It is required to prove that if $a = b$, and $\alpha = \beta$, then $\phi = \theta$. Procedure in developing the proof is as follows:

Drop a perpendicular *PQ* from *P* to plane *AOB;* draw *QR* perpendicular to *AO* in plane *AOB;* draw *QS* perpendicular to *BO* in plane *AOB;* draw *PR* and *PS*. From the construction of the joint of *Fig.* 3, triangles *COP* and *DOP* were found to be congruent; therefore $PR = PS$ because they are perpendiculars dropped from *P* on sides *a* and *b* respectively. Triangles *PQS* and *PQR* are, therefore, congruent because they have equal hypotenuses and a common side. Therefore $\phi = \theta$.

It has now been proved that the joint of *Fig.* 3 transmits motion with a constant velocity ratio. Any joint designed on this principle will, therefore, also transmit motion with a constant velocity ratio.

BENDIX-WEISS JOINT[3]: This joint is shown in *Figs.* 1 and 5. The sketch, *Fig.* 5, shows the joint with the right-hand yoke rotated through 90 deg to simplify the drawing and to show more clearly the relations of the grooves. As can be seen from the illustrations, grooves which are symmetrical with respect to each other about the center lines of the shafts are formed

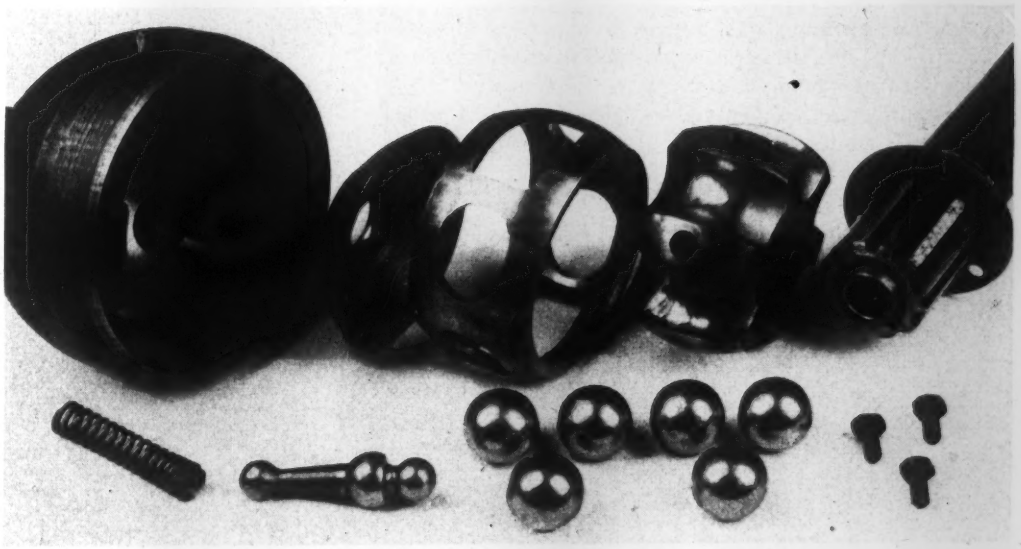


Fig. 6—Above and Right—Assembled and disassembled views of the Rzeppa constant-velocity joint

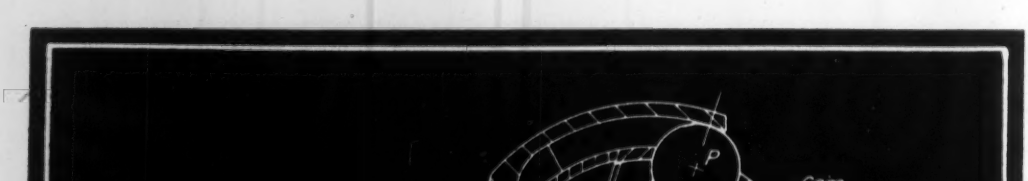


Fig. 7 — Cross section through Rzeppa joint showing how the balls are positively located by a cage and piloting mechanism

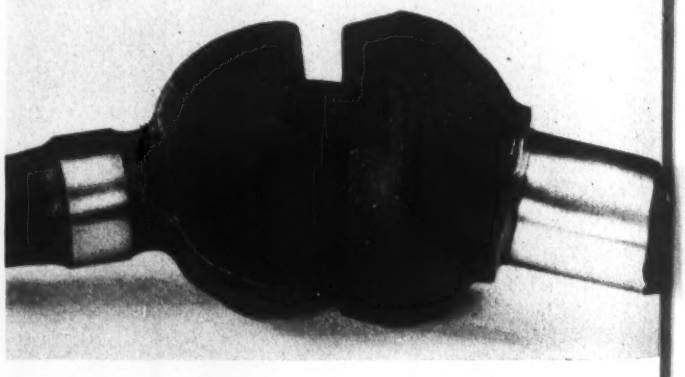
in the surfaces of the prongs of the yokes, and four steel balls are located between these prongs at a point where the axes of the grooves in one yoke intersect the axes of the grooves in the other yoke. The grooves are not concentric but are struck with a single radius from a center on the shaft axis. Power is transmitted from the driver to the follower through these balls. A fifth ball with a slot provides for locking of the parts in assembly as well as for taking end thrust.

If a comparison is made between the design of the Bendix-Weiss joint as shown in *Fig.* 5 with that of the theoretical joint of *Fig.* 3, it can be seen that the Bendix-Weiss joint fulfills the same conditions of symmetry as does the theoretical joint. Therefore, the balls will automatically shift their positions as the angular displacement of the two shafts is varied so that the plane containing the centers of the balls will always bisect the angle of displacement of the two shafts. The Bendix-Weiss joint, therefore, is capable of transmitting motion with a constant velocity ratio in accordance with the proof given.

RZEPPA JOINT: A bell-type Rzeppa joint is shown in *Figs.* 6 and 7. The joint consists of a spherical housing and an inner race with corresponding grooves in each part. Six steel balls inserted in these grooves transmit torque from the driver to the follower. The grooves are made concentric with the intersection, *O*, of the shaft axes.

It may be recalled that in *Fig.* 3 the ball in the theoretical joint is maintained in its correct position by the action of the grooves. In the bell-type Rzeppa joint, however, the balls are positively located by a cage and a piloting mechanism. The six balls are carried in a cage, *Fig.* 7, whose position is controlled by a rod. One end of this rod engages a socket in the end of shaft *B* while the other end slides in a hole in the end of shaft *A*. A spherical enlargement on the rod engages the cage.

If the shaft *B* is deflected with respect to the shaft *A*, it must pivot about *O* as a center because



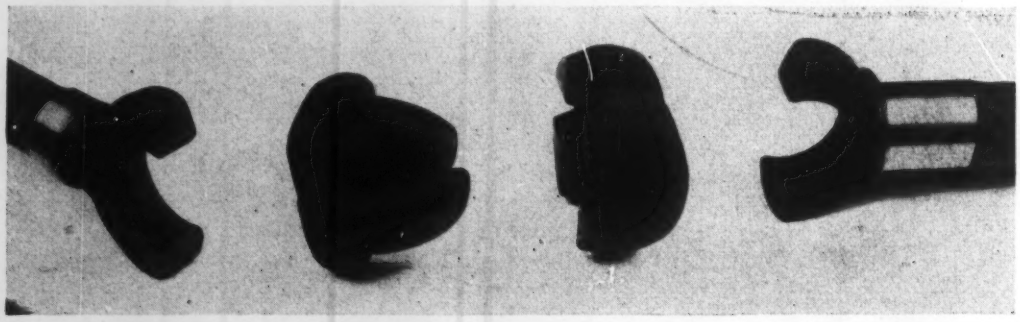


Fig. 8—Above and Left—Assembled and disassembled views of the Tracta constant-velocity joint

the unit is concentric about *O*. Through the motion of this shaft, the rod is actuated, in turn moving the cage, and hence the balls, through approximately half of the angle turned through by the shaft *B*.

Although it is possible to prove geometrically that the angle between the shafts is exactly bisected by the plane of the centers of the balls for one and only one angle (other than zero) between the shafts, depending upon the proportions of the piloting mechanism, the deviations are so slight for other angles up to about 40 deg as to be negligible. For all practical purposes the plane of the centers of the balls bisects the angle between the two shafts, and the joint transmits a constant angular velocity ratio.

TRACTA JOINT: The Tracta joint consists of four parts as illustrated in *Fig.* 8: Two shafts with forked ends and two hemispherical parts, one of which has a tongue and the other a groove to receive this tongue. In addition each of the hemispherical bodies is provided with a groove which permits the connection of a fork. The forks subtend an angle greater than 180 deg so as to be self-locking when assembled. The tongue and tongue-groove are at right angles to the grooves which admit the forks. By means of the union of the tongue and groove when the joint is assembled, the axes of the hemispherical parts must always remain in the same plane. When the joint is assembled, the forks are free to rotate about the axes of the hemispherical bodies which lie in the plane of the tongue and groove.

The joint is held in proper alignment for industrial application by two spherical housings not shown. When assembled, these provide a ball-joint type of housing which supports the shafts so that their axes will intersect at all times at a point equidistant from the centers of the hemispherical members.

An elevated view of the joint is shown in *Fig.* 9*a*. The intersection of the centerlines of the shafts *A* and *B* is represented by point *O*. Points *C* and *D* represent the centers of the male and female parts respectively; as already mentioned, they must be equidistant from point *O*.

In *Fig.* 9*b* is shown a sketch of the joint where the shafts have been rotated through 90 deg. Through centers *C* and *D* are drawn axes of the hemispherical parts. These axes also represent the axes of rotation of the forks and are perpendicular to the center lines of the shaft. Because of the alignment of the hemispherical parts by means of the tongue and groove, these lines will always lie in the same plane, and, if extended will intersect at point *P*. Twice during each revolution these lines will be parallel, and may then be considered to intersect at infinity. The length *CO* equals the length *DO* and the angle *PCO* equals the angle *PDO*. Therefore the conditions of symmetry have been met and it can be proved in the same manner as applied to the joint in *Fig.* 3 that the Tracta joint can transmit motion with a constant velocity ratio.

The author wishes to acknowledge the helpful criticisms of Professor G. A. Nothmann, of Cornell University in the preparation of this article.

REFERENCES

1. Albert, C. D., and Rogers, F. S.—*Kinematics of Machinery*, John Wiley & Sons Inc., New York, 1938.
2. Steeds, W.—"Universal Joints," *The Automobile Engineer*, London, Jan., 1937.
3. Sturges, E. B.—"Constant-Velocity Universal Joints," *Product Engineering*, July, 1947. This article presents a different treatment of the Bendix-Weiss joint.

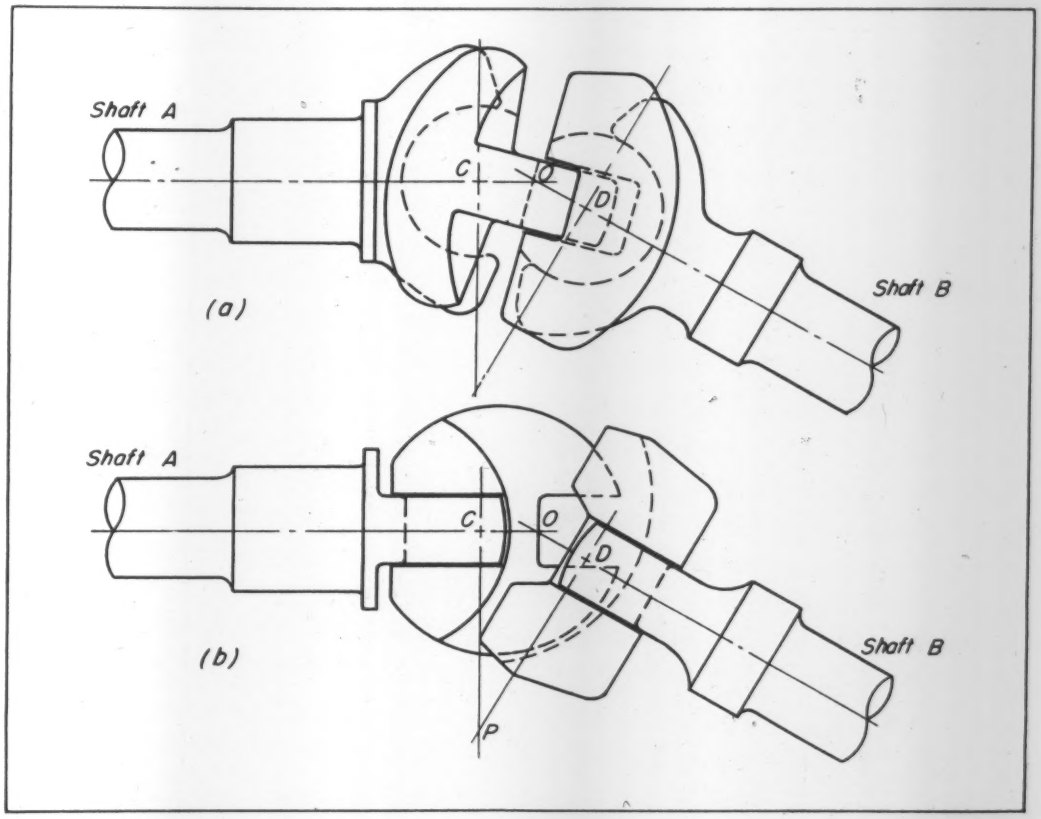


Fig. 9—Two views of the Tracta joint drawn for shaft rotational positions 90 deg apart

Elastic Matching

By J. G. Baker
Chief Engineer
Baker Manufacturing Company
Evansville, Wis.

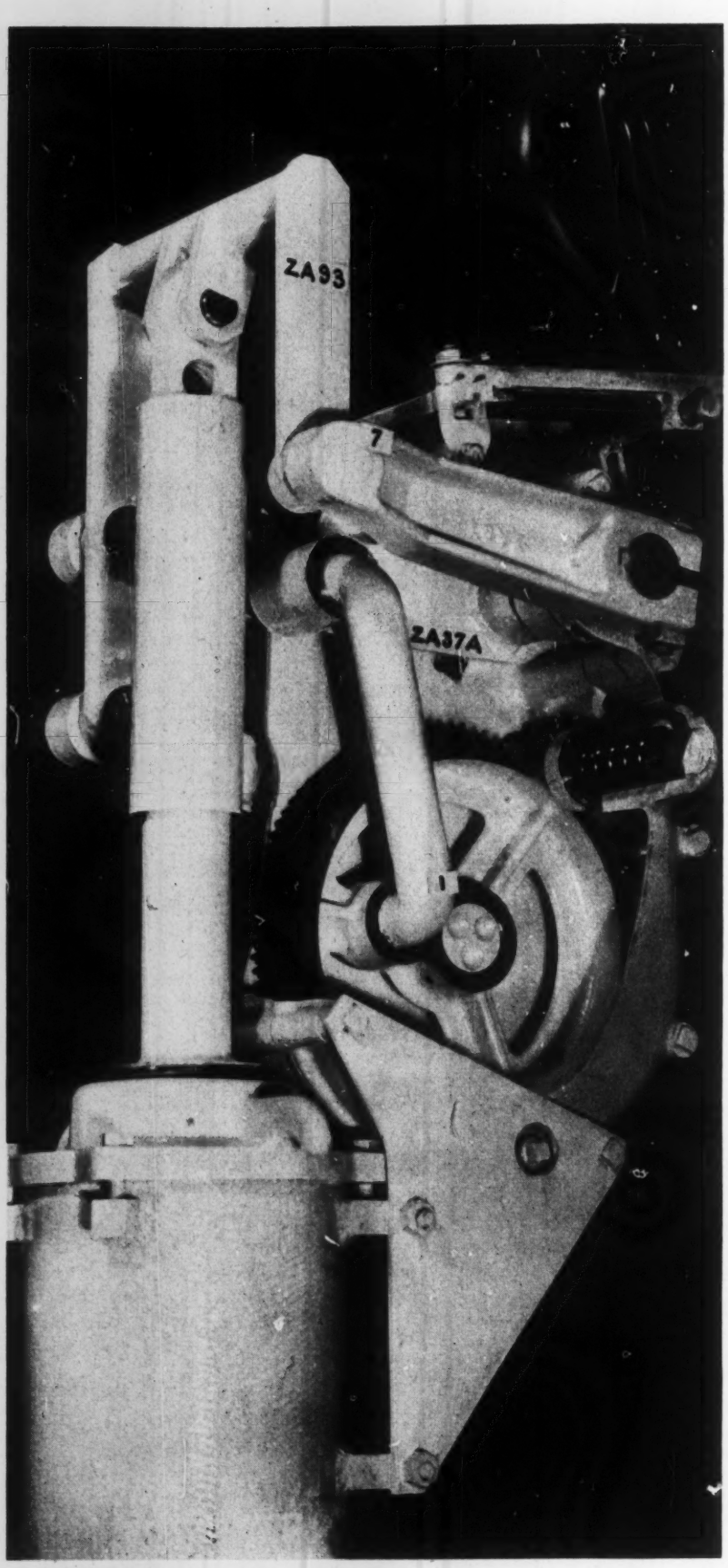


Fig. 1 — Weldments are used in this pump head to match the elastic properties of connected parts

ADDED cost is often introduced in mechanisms, such as that of *Fig.* 1, to avoid nonuniform loading of bearings, or bearing misalignment as the result of loading. The use of self-aligning bearings to accommodate shaft load deflection is a case in point. The three views of *Fig.* 2 illustrate another case. View *a* shows an unloaded pin connection. Under load in an extreme case the distortion may force the pin against the bottom of the bearing as shown in view *b*. In milder cases the bearing is simply loaded nonuniformly along its length.

The design of view *c* largely avoids this problem through the addition of another pin support. However, the additional cost of the extra support may be significant. For example, the crank mechanism of *Fig.* 3*a*, in which the crankpin is overhung, is less expensive than either that of designs *b* or *c* in which the crankpins are doubly supported. Design *b* is more expensive than *a* because it requires a crankshaft with the usual machining and connecting-rod bearing connection complications. Design *c* is more expensive than *a* because an extra gear and pinion are required and because it is difficult to obtain a sturdy gear-crank pin assembly.

AN AWARD-WINNING paper in the recent "Design-For-Progress Program" sponsored by The James F. Lincoln Arc Welding Foundation. Proper loading of bearings is achieved by matching the elastic deflections of bearing supports and shaft elements. Discussion includes basic concepts and calculations

...mproves Bearing Life and Performance

PRINCIPLE OF ELASTIC MATCHING: Selecting the elastic properties of a machine element to insure that the line of action of a bearing load remains in the center of the bearing under all working loads will be designated herein as *elastic matching*. Elastic matching eliminates bearing misalignment due to load and greatly reduces nonuniformity of bearing pressure due to load.

How the design of *Fig. 2a* may be altered to obtain elastic matching is indicated in *Fig. 4a*. *Fig. 4b* shows how compensation is effected by the matched angular deflections of both loaded members. It is likely that on occasion the choice of *b* or *c* in preference to *a*, *Fig. 3*, has been made for other reasons than the deflection problem encountered with *a* (in high-speed applications the extra weight of the pitman in *a* would be reason enough not to use it). It is also true that designs have been made of the *Fig. 3a* type without regard for the deflection problem. With plausible proportions and heavy loads concentrated in the center of the pins, the theoretical angular deflection of the pitman results in the pins going out of parallel about five times as much as ordinary bearing clearances would allow with the rest of the parts rigid. This means that under actual conditions, before wear is significant, the center of the bearing load shifts to the ends of the bearings under even light compressive or tensile loading, and severe cramping of the bearings is to be expected upon the application of heavy loads.

Illustrated in *Fig. 5* is a method of elastic matching for loaded shafts. The bearings are supported in thin panels located at distances d_1, d_2, d_3 and d_4, respectively, from the center of the bearing in each case. The distance d for each panel is selected so that the angular deformation at the bearing is equal to and in the same direction as the angular deformation of the shaft at the bearing when the line of ac-

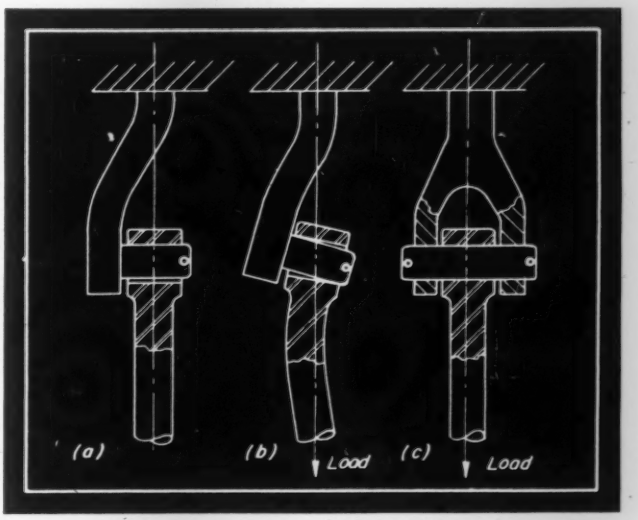
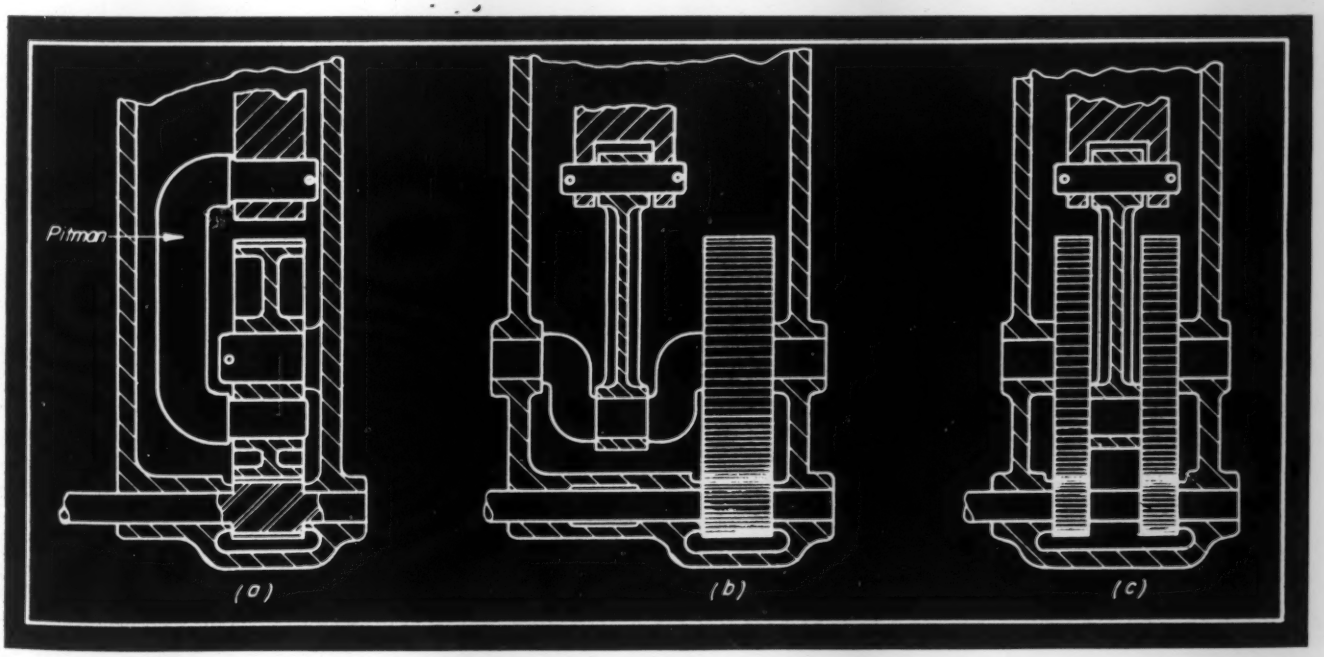


Fig. 2—Above—(a) Singly supported bearing pin, no load; (b) Singly supported bearing pin with load; (c) Doubly supported bearing pin

Fig. 3—Below—Three types of crank and crosshead units



tion of the bearing load is in the center of the bearing.

Elastic matching may be used in a wide variety of cases. Matching may be desirable for purposes other than improving bearing performance and wear resistance, but such improvement is doubtless the most important application. Elastic rotation, twisting or bending, or combinations of these may be matched.

THEORY OF ELASTIC MATCHING: Usually the design of the pin or shaft member such as the pitman of *Fig. 3a* is more or less determined by consideration of cost, strength and available space. In the typical case of elastic matching, the elastic properties of an adjacent member such as the top member in *Fig. 3a* are selected to match those of the pin or shaft. The latter will be referred to as the given member, the former as the adjacent member.

Example Cited

To clarify the meaning of elastic matching, imagine that in the case of *Fig. 4a* the material of the bearing is removed except for a small contact zone in the middle of the bearing. Assume elastic behavior and let:

C_1 = Load angular stiffness of the given member referred to the center of the bearing (pounds per radian)

d = Distance between the center of the bearing and the center of twist or bending of the adjacent member (inches)

K_2 = Moment angular stiffness of the adjacent member (inch-pounds per radian)

L = Bearing load (pounds)

θ_1 = Angular deflection of the given member

θ_2 = Angular deflection of the adjacent member

From the definition K_2 and C_1

$$Ld = K_2\theta_2 \quad \ldots\ldots (1)$$

$$L = C_1\theta_1 \quad \ldots\ldots (2)$$

Elastic matching occurs when $\theta_1 = \theta_2$, which means, from Equations 1 and 2

$$d = \frac{K_2}{C_1} \quad \ldots\ldots (3)$$

Value C_1 is such that the larger K_2 the larger d and the larger the moment on the adjacent member for a given load L. Therefore the greater the stiffness of the adjacent member the greater must be its strength for moment resistance.

Now compare two adjacent members for the same purpose, one $\frac{1}{4}$-inch thick and the other $\frac{1}{8}$-inch thick. Assume that bending stiffness governs and that the Young's moduli are equal. The thick part will have eight times the stiffness because stiffness in bending depends on the cube of the thickness. From Equation 3, eight times the stiffness means eight times d, and eight times d means eight times the bending moment with a given load. The strength of the thick part to resist moment for a given stress will be four times that of the thin part. Hence for a given bearing load L, the working stress in the thick part will be twice that of the thin part. Thus the thin part is stronger than the thick part by a factor of two if the permissible stresses are the same. It is concluded that for elastic matching it is important to have the adjacent member thin.

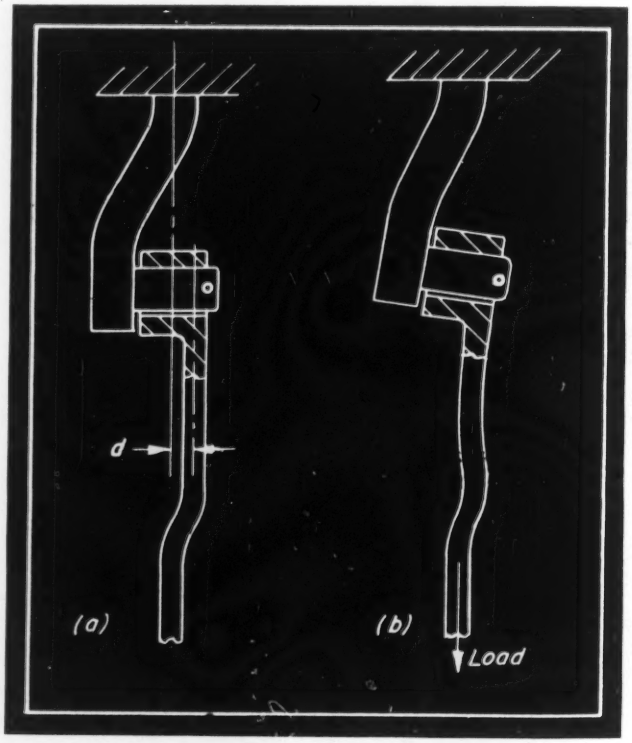


Fig. 4—Above—(a) Singly supported pin and bearing with elastic matching, no load; (b) Singly supported pin and bearing with elastic matching, loaded

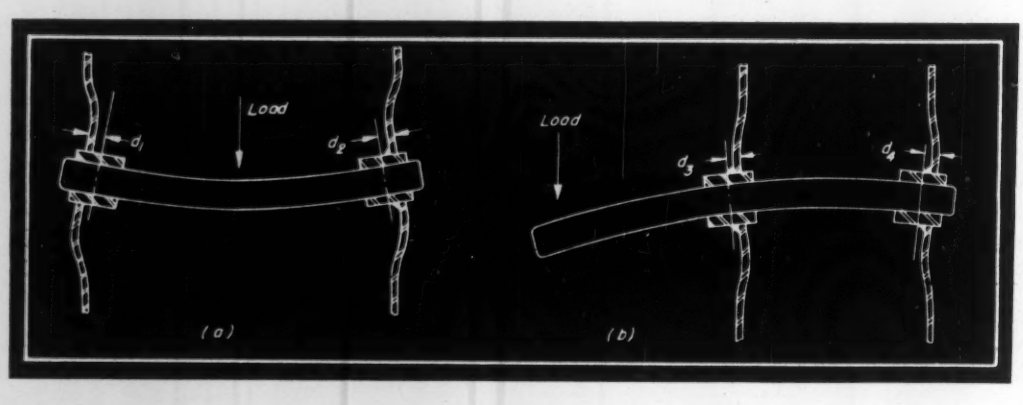


Fig. 5 — Left — Straight shaft bearings with elastic-matching

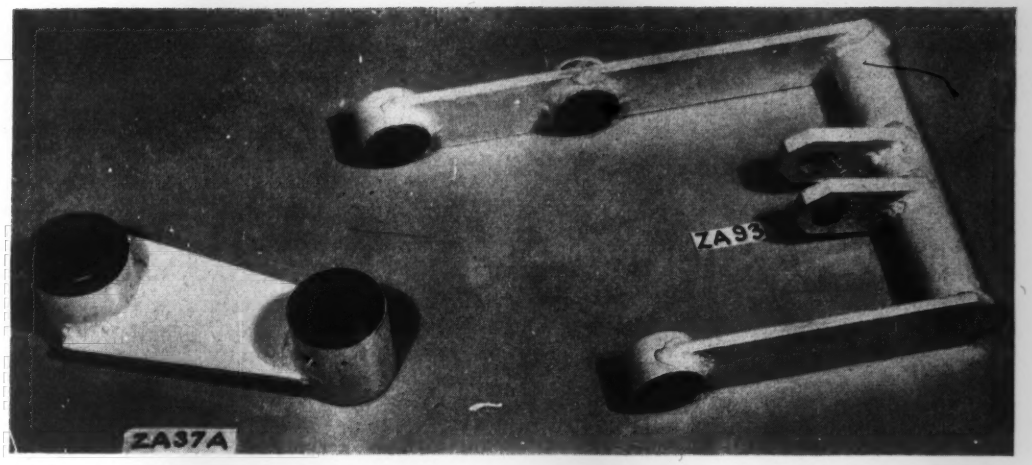


Fig. 6—Weldments designed for elastic matching

In cases like those of *Fig.* 3*a* and *Fig.* 5*a* it is of interest to know how far the center of bearing pressure is moved from the center of the bearing by an error in selecting the location of the center of bending of the adjacent member. Only small movements need be considered because a large movement would mean excessive nonuniformity in load distribution or even cramping of the bearing due to misalignment.

For small movements of the center of bearing pressure, neglecting the effects, if any, of lateral deflection* let:

K_1 = Moment angular deflection of the given member

X = Distance between the center of bearing pressure and the center of twist or bending of the given member

a = Distance between the center of twist or bending of the given member and the center of twist or bending of the adjacent member

From the definitions of K_1 and K_2

$$LX = K_1\theta_1 \quad \ldots\ldots (4)$$

$$L(a - X) = K_2\theta_1 \quad \ldots\ldots (5)$$

Since θ_1 must equal θ_2 with the load anywhere near the center of the bearing, it is found from Equations 4 and 5

$$X = \frac{K_1 a}{K_2 + K_1} \quad \ldots\ldots (6)$$

If a is off from what it should be for elastic matching by an amount Δa, then the center of pressure moves ΔX which is simply determined from Equation 6 by differentiation

$$\Delta X = \frac{K_1 \Delta a}{K_2 - K_1} \quad \ldots\ldots (7)$$

Should the stiffness K_1 of the adjacent member be made small, as it was shown above that it should be, then from Equation 7 the movement of the center of pressure ΔX is approximately equal to and in the same direction as the error Δa in the choice of location of the center of twist of the adjacent member. This means that for sleeve and roller bearings, where the load center may shift perhaps one-quarter of the bearing length without harm, an error in location of the center of twist of about one-quarter the bearing length is permissible. This rather large permissible error is important, for in such an actual case the parameters C_1 or K_2 may vary making an error in the selection of the location of center of twist unavoidable.

Without reference to the above it is obvious that if the stiffness of the adjacent member is sufficiently small in comparison with the stiffness of the given member, even a d distance of zero would be acceptable.

Fabrication of a part with bearing bosses supported by relatively thin webs or panels as required for elastic matching is most easily effected by arc welding. The sudden section changes in such parts make casting or forging difficult. A sudden change in section of a casting is conducive to shrink holes produced by the solidification of the light sections before the heavy sections. In addition, the casting process is not suited to thin sections where considerable strength is required. With forging, the sudden transition means difficulties in getting metal into the heavy part of the die and out of the light part. The forging of a part like *ZA*-93, *Fig.* 6, which contains a length of tubing is of course out of the question anyway.

Riveting Not Practicable

Although light sections adjacent to heavy sections can be riveted there are three serious objections to riveting in the fabrication of adjacent members where elastic matching is used. First, the length of the thin section contributing to the needed flexibility is reduced by the length of the joints. In part *ZA*-37*A*, *Fig.* 6, for example, joints each made with a single row of rivets would occupy at least one third of the available length, with the result that the strain per unit length would be increased 50 per cent. Second, the strength of the riveted joint with a single row of rivets would be only about one-half the

* This would not be permissible in the case of *Fig.* 5 if the bearing spacings were short.

strength of the welded joint. Third, simple cylindrical bosses as used with arc welding would no longer be suitable.

In the reciprocating pump head shown in the photograph, *Fig.* 1, the principle of elastic matching has been applied. The internal mechanism is on the pattern of *Fig.* 3*a*. Elastic properties of the pitman are matched by the elastic properties of the weldment (*ZA*-37*A*), with the result that the bearing pressure is centralized for *both* pitman bearings. Referring to the external mechanism of the pump head, the elastic properties of the cranks (7) are matched by the elastic properties of the weldment *ZA*-93.

Test Set-up Checks Calculations

As a check of the elastic matching calculations in the case of the pump head, the test set-up shown schematically in *Fig.* 7 was made. In this set-up a special gear with rigidly attached tube extensions was used to replace the regular gear of the pump head. A square rod was rigidly attached to the pitman and a clearance was provided all around the pitman bearing so that there was no direct contact between pitman and the gear tube assembly.

In order to put a load between the pitman and the gear to simulate an actual bearing load properly located in the center of the bearing, a headed rod was provided extending from a socket in the pitman bearing to a nut at the end of the vertical tube extension. This nut was used to put tension in the headed rod, and the headed rod was long enough to permit a small axial movement of the pitman bearing, which is necessary for elastic matching. (Under actual conditions this movement involves very little friction resistance because of the concurrent rotation of the journal with respect to the bearing.) The whole assembly was mounted in the regular pump head case (not shown in *Fig.* 7), the case being cut away to avoid interference with the tube extensions.

The test was made with both shafts blocked against rotation. Two positions of the special gear were used and both $d = 9/32$-inch and $d = 5/32$-inch values were used for each position. Deflection of the square rod was measured by the dial indicators at the points shown, angular deflection being obtained by simply dividing the difference between the reading increments by the distance between the indicators.

It was found that in changing from $d = 9/32$-inch to $d = 5/32$-inch the relative angular deflection reversed. Thus the ideal d was between the two values tested, and the position of the center of pressure was, from Equation 6, about 1/16-inch from the center of the bearing for either d tried.

TABLE I

Wear in Inches on Bearings of Pitman, Fig. 1

	Inner End	Middle	Outer End
Top Bearing	0.001	0.0005	0.001
Bottom Bearing	0.0026	0.0024	0.0022

With $d = 9/32$-inch, the pump head was operated with a maximum load in excess of one-thousand pounds on the well rod for over 3,400,000 cycles. TABLE I shows the wear measurements. If it is taken into account that some nonuniformity in wear is inevitable, the wear test results in TABLE I evidently confirm that elastic matching existed.

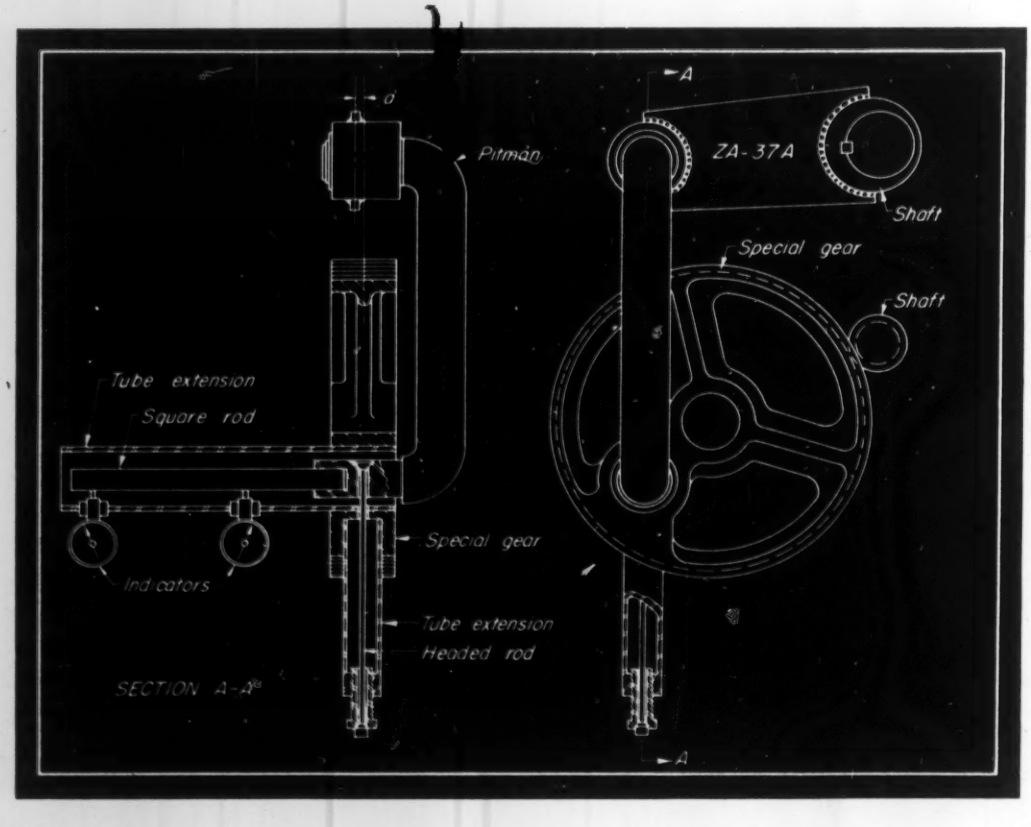
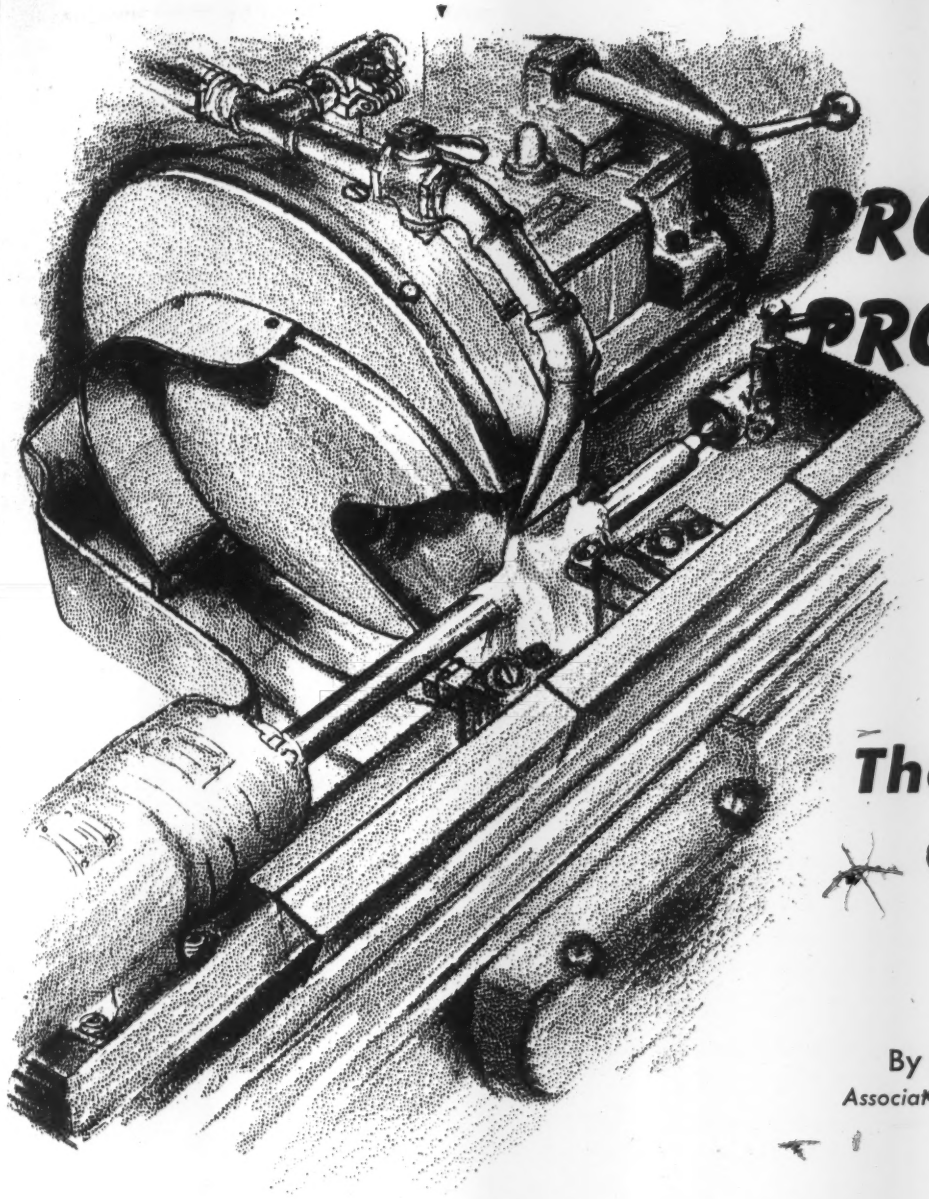


Fig. 7 — Experimental set-up for checking elastic matching



PRODUCTION PROCESSES...

Their Influence On Design

By Roger W. Bolz
Associate Editor, Machine Design

Part XXXIII–Production Grinding, Design Factors

PRECISION grinding permits the design and manufacture of machine parts to extremely close tolerances and quality of surface finish not readily attained with other machining methods. It oftentimes permits the designer to proportion a part in accordance with functional requirements and achieve size or weight savings made possible by the use of materials which cannot be readily machined by other methods. Too, the degree of accuracy now offered by modern grinding equipment, discussed in the previous article of this series, has ushered in a new era of superprecision mass production and broadened the field of interchangeable manufacture, *Fig.* 19.

Although some parts, as always, will necessitate specially developed production equipment, the great majority of parts, to afford maximum economy in production, should be designed to allow the use of standard equipment. Though quantities to be produced may run from but few pieces to large quantities, the same advantages will accrue in the elimination of production problems.

Economy in production, as in other manufacturing methods, is to a large extent determined by part design. Maximum simplicity dictates a minimum number of separate grinding operations on each part. consideration of ease in holding, locating or clamping, a minimum thickness of stock to be removed, minimum variation in stock allowance within a production lot, minimum area of material to be ground, etc. With parts to be ground, therefore, centerless and surface grinding merit consideration in achieving lowest production costs.

Careful attention to the multitude of problems incident to practical fixture design with parts not suited

to center, centerless, magnetic chuck grinding, etc., will assist greatly in assuring rapid loading, accurate and easy locating, solid clamping without distortion, and no wheel interference, *Fig.* 20. Elimination of hard-to-reach, complex surfaces wherever possible as well as any slow loading or grinding operations will help insure the advantages of minimum production time and maximum quality.

It is important in developing the design details of machine parts to give careful thought toward elimination of interrupted surfaces immediately adjacent to full continuous cylindrical surfaces which serve as bearings. The grinding action of the wheel engaged with both the full as well as the interrupted surface may cause a reflection of the interruptions into the continuous surface. Solution is to have the interrupted surface slightly smaller in diameter or have it separated from the adjacent surface by a clearance or undercut, *Fig.* 20.

Some care must also be given to the design of ground parts so that those surfaces which require finishing can be readily reached with a practical size of grinding wheel and, in some cases, a wheel of size suitable for the machine necessary to use. Projections on parts should never shroud over a surface to be ground in such a way as to require grinding with a small-diameter wheel approaching the work at an undesirable angle.

Precision cylindrical grinders permit establishing accurate radii for fillets as well as square or tapered shoulders adjacent to cylindrical surfaces. However, unless design dictates otherwise, it is preferable to substitute a relief for a fillet owing to the ever-present problem of maintaining the corner of a wheel trued to the accuracy limitations on radii. Wherever critical stress concentrations are not expected, a relief should be employed, *Fig.* 21, and production often can be increased to as much as double by this means. *Fig.* 21 also indicates the preferable method of grinding a diameter and an adjoining square shoulder in one operation with the grinding head set at an angle of 30 or 45 degrees. This method results in a concentric grinding pattern on the face which is desirable where that surface is to be used as a thrust bearing. If a universal machine is not available and a plain grinder is employed the preferable method from an economy standpoint is to feed the wheel into the corner, thus finishing the shoulder, but this results in a criss-cross pattern which may be undesir-

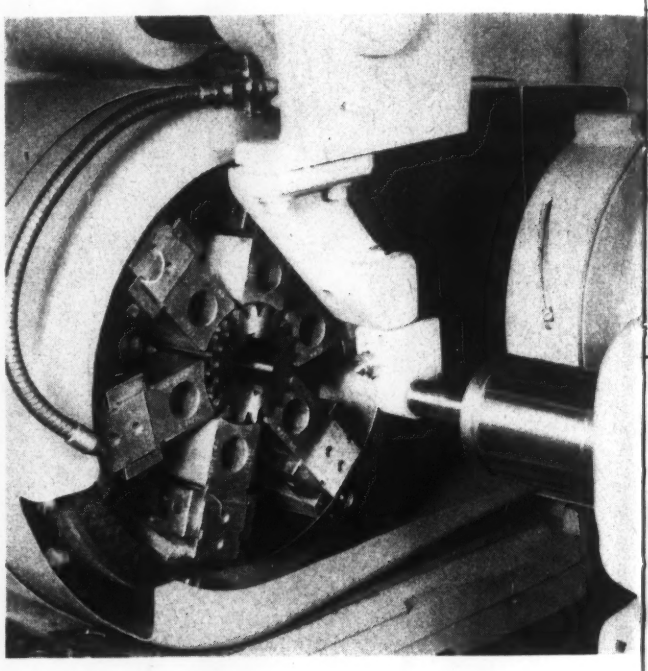


Fig. 19 — Above — Bryant 112-Ah two-spindle chucking grinder for high-production work requiring simultaneous finishing of hole and face to assure squareness relationship

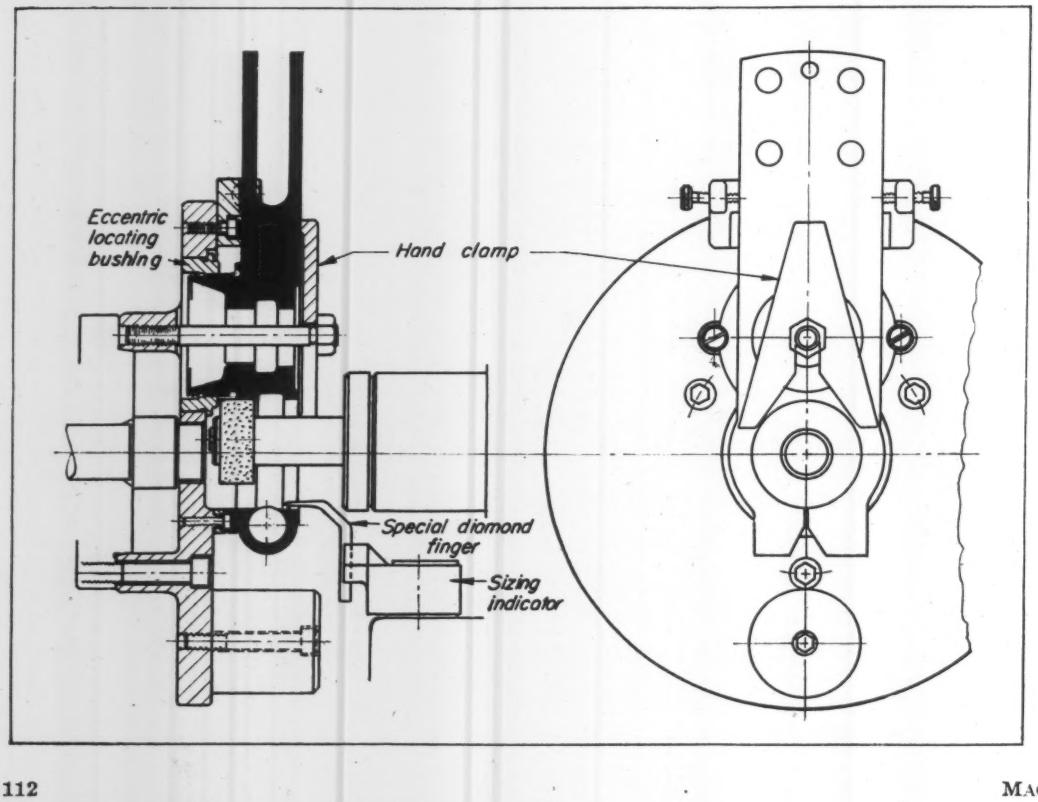
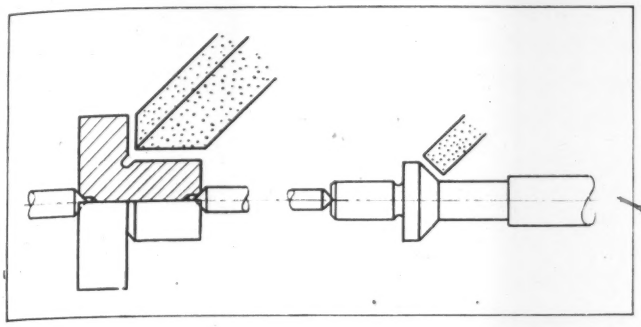


Fig. 20 — Left — Complex designs such as this crankshaft part often present difficult fixture and loading problems



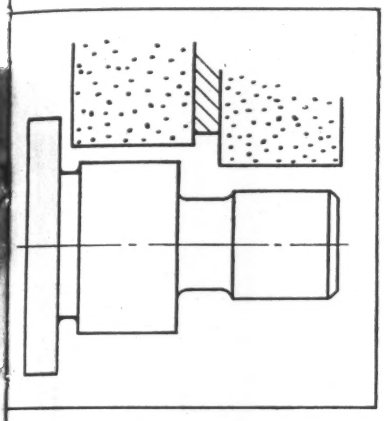


Fig. 21—Above—Where fillets are not a design "must", reliefs or undercuts improve production possibilities

Fig. 22—Left—Relieved portions between adjoining diameters improve production and allow automatic grinding in production

able depending upon the application.

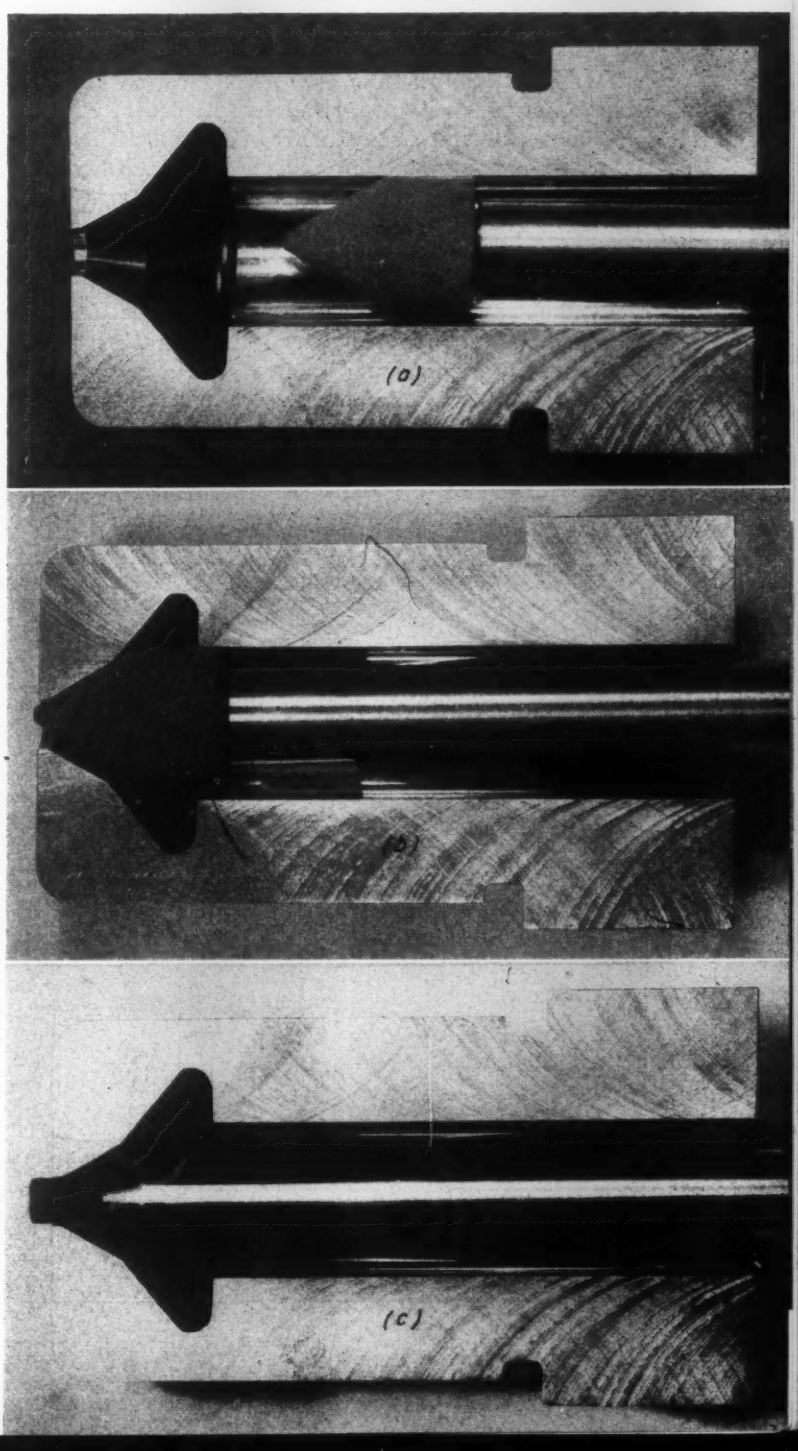
To simplify production, reliefs should also be used in lieu of fillets where adjoining diameters are to be ground. Providing smoothly blended contours are not demanded for strength characteristics, the use of reliefs makes possible much greater output by elimination of extra wheel dressing and grinding operations. Often parts can be plunge-cut with several wheels or a wide wheel in but a fraction of the time, using automatic handling, *Fig.* 22. In all cases reliefs should be as wide as possible. In depth the relieved portion should be recessed sufficiently so that the wheel does not contact on reaching minimum grinding size.

Fillets should also be used in specifying ground-thread parts to allow for wheel clearance. Where desirable, the leading and trailing portions of imperfect threads can be removed as in thread milling.

Where fillets are necessary, consideration should be given to a number of important factors. First, it is desirable to keep fillets as large as possible; a small corner radius on a wheel requires more frequent dressing and should seldom be less than 0.010-inch; on diamond-dressed formed wheels, fillet radii to be generated such as at the root of threads should never be less than about 0.017-inch inasmuch as smaller radii are difficult to retain on a frigile, sharp-pointed diamond. Second, if a radius must blend into adjoining surfaces to prevent formation of fatigue cracks, again the radius should be as large as possible; a large radius is much easier to blend. Third, wherever possible the grinding of a fillet should be avoided and cost will usually be reduced, and in such cases the drawing should indicate how far the grinding must go to a forged, cast or machined fillet. Fourth, on a single piece, fillets specified should be identical to make possible finishing of all without separate wheel truings. Fifth, sharp corners should be avoided; if design does not require a fillet, an undercut or relief is the practical substitute. Sixth, in order to obviate the necessity for holding extremely accurate limits on fillet radii, attention should be given to the fit of mating parts so that ample clearance is guaranteed without close fillet tolerances.

Wherever center grinding is indicated, part design should contemplate the use of center holes which can be retained throughout the processing of the part as this often offers an economy in manufacturing. To insure accurate grinding, center holes must be in accurate alignment, perfectly round and, if necessary, lapped smooth. To minimize chatter, center holes

Fig. 23—Below—Views showing grinding of a fuel injection nozzle, (a) straight hole, (b) taper seat, and (c) 0.040-inch injection hole



should be as large as practicable. Again, to reduce handling difficulties and avoid the necessity for complicated counterbalanced fixtures, it is highly desirable that parts to be ground be naturally balanced about the center of grinding. Otherwise, complications from vibration may result, although fixture design often can obviate such problems where unbalanced design is essential, *Fig.* 20.

As a rule, in internal production grinding, holes under 0.040-inch are impractical and should be avoided, *Fig.* 23. Smaller holes are often ground in tool and die work but necessitate the use of a jig grinder with diamond-charged mandrels. Again, as in external work, provision of grinding relief for wheel clearance should be kept in mind, *Fig.* 24. Addition of an undercut which has been overlooked on the drawing may seriously weaken a part and may, in certain cases, amount to almost 50 per cent of the section. Another detail is relieving the center of a face, *Fig.* 24, which again allows the wheel to finish off the surface and preserve the edge. Also, it may be impractical to use a bottom relief in which case part design should take into consideration the fact that the wheel will not grind to full depth, *Fig.* 25.

Where external operations can be substituted for internal ones, production will be considerably simplified and costs often reduced considerably, *Fig.* 25. Designing to keep internal finished holes to a simple cylindrical shape will prove most economical in production.

In dimensioning a part, location of critical faces or forms must be properly shown if accurate grinding and correct angular relationhips are to be expected. Only by locating critical points of a part from that one point which bears a specific relationship to the final assembly of parts, can complete interchangeability be assured, *Fig.* 26. Tolerances may be cumulative and result in errors not anticipated. As a rule, critical locating points should be as close as possible to the surface or form that is to be ground.

In designing for centerless grinding, certain limitations over and above those mentioned in the preceding portion of this article should be kept in mind. Shape at the end of cylindrical parts which require grinding along with the diameter requires consideration. Although a full radius can be generated by the use of carefully diamond-trued wheels, this is expensive. To ease the problem a slight flat at the end should be acceptable. When crush-dressed wheels are used a flat is unavoidable and a full spherical form is uneconomical in dresser life. The most satisfactory end design is about a 120-degree angle as shown in *Fig.* 27. Where long, slender formed parts, *Fig.* 28, are designed these should be considered for centerless production to obviate the difficulties in center grinding such parts and depth of form as well

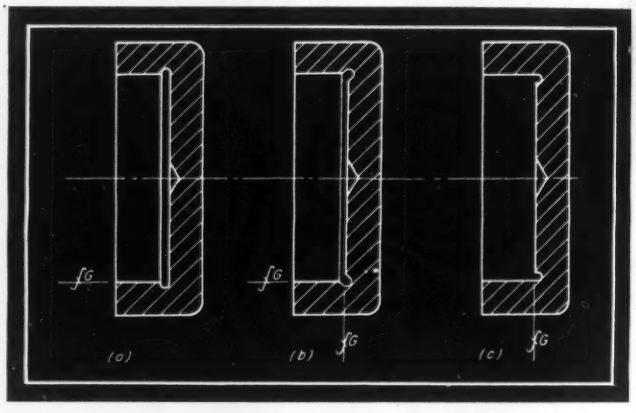


Fig. 24 — Above — Provision of grinding relief on internal work should be as at (a) for diameter only, (b) diameter and face, and (c) face only

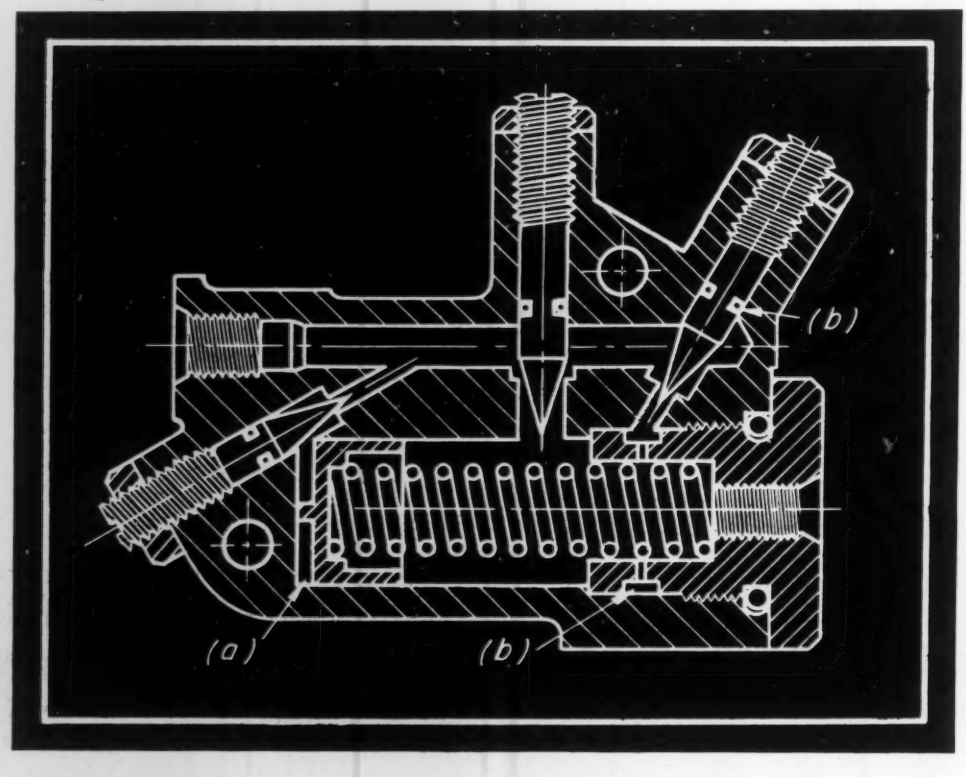


Fig. 25—Left—Part design should allow for bottom clearance, (a) on holes and external operations, (b) should be used in preference to internal ones for simplifying production of parts

as length should be suited to the capacity of the machine available.

In surface or face grinding, as in the other methods of grinding, cost is directly tied up to volume of stock removal. Surface area to be finished, therefore, should be kept to a minimum. Surfaces should be relieved to offer only the necessary area required for matching or fitting, *Fig.* 29. If opposing surfaces are to be ground, the possibility of grinding in an opposed-wheel grinder should be kept in mind. In this case it is usually essential that the opposing surfaces be similar and of identical area. To adapt a design for surface or face grinding, no projections or steps in surface level should be present. One operation then can be used to machine completely to finished tolerances the entire face, *Fig.* 30. For securing the finest finish and maximum flatness in surface grinding, the part should be reasonably thick with respect to its length and width or diameter. Thin sections may spring slightly during grinding, producing an uneven surface finish or undesirable variations in flatness. Where control of dimensions rather than surface finish is the prime objective, partly unfinished portions should be acceptable to make possible minimum stock removal and speed up production. Care should be exercised with hardened parts so as not to remove the hardened case in grinding to finish dimensions.

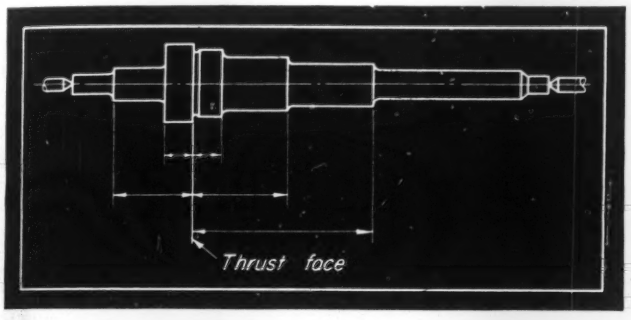
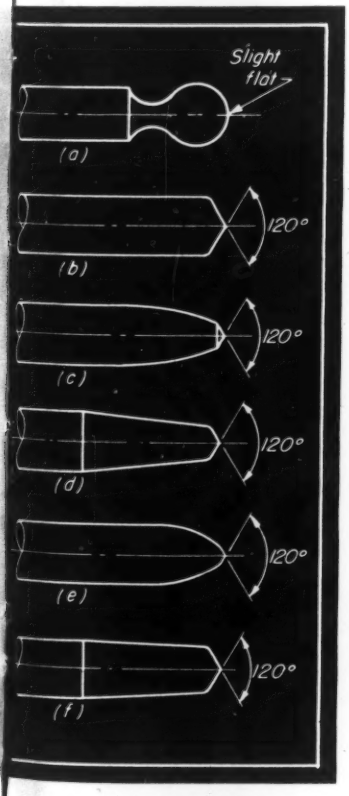


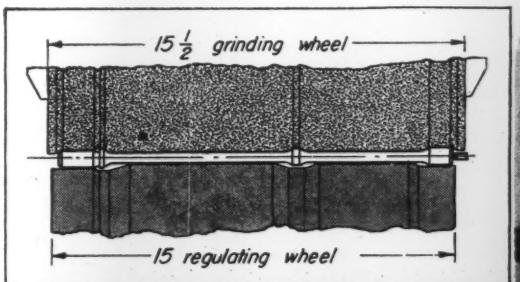
Fig. 26—Above—Key location point of an assembly should be used in dimensioning to insure accurate grinding

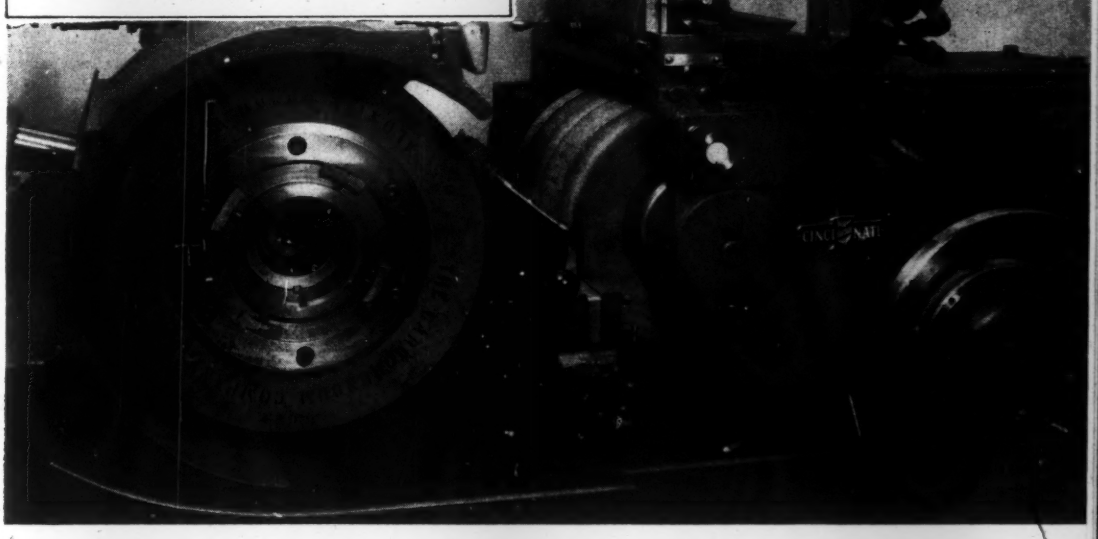
Fig. 27—Left, Below—Alternative end forms for centerless-ground parts. Those shown in b,c,d,e, and f are most easily produced

Fig. 28—Right, Below—Long, slender formed parts are easily produced on centerless machines without difficulty from deflection during the grinding process

Stock allowed for surface grinding thus need only be a bare minimum. While cuts of ¼-inch depth or greater are possible, for obtaining maximum economy in production, about 1/16-inch and preferably even less should be allowed. On cylindrical parts to be ground, external stock allowance of 0.005-inch is the best practical minimum amount. Additional allowance, however, must be made over this base figure to compensate for such unknown variables as normal material twist or warpage, part warpage in hardening, eccentricity in turning, turning tolerances, centering tolerances, etc. Once the full effects of any or all such variables are known, final minimum grinding allowance can be specified. For holding the best possible accuracy in grinding, stock allowances must be uniform and this factor should be kept closely in mind. In a single batch of parts, if the stock allowance varies widely from part to part, automatic-cycle machines may be grinding "air" on a large number at the beginning of the automatic-feed cycle inasmuch as the machine must be set to begin "feed" for the largest diameter blanks. Minimum variation





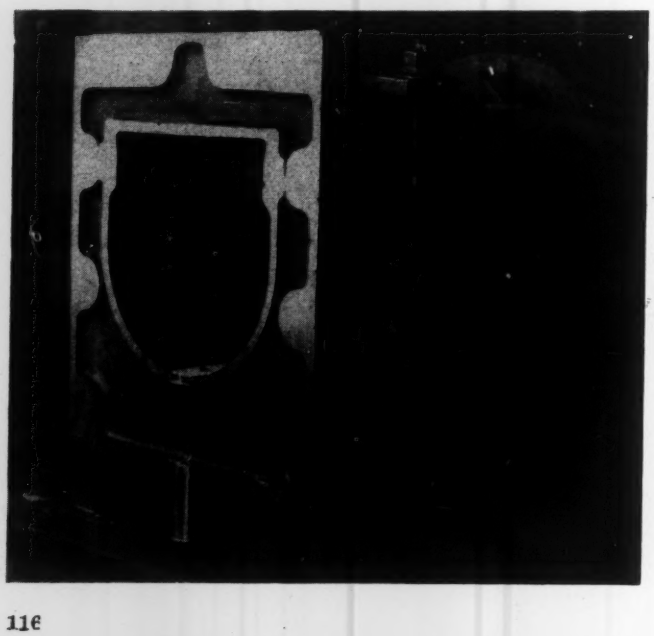


from part to part can in this way effect considerable savings in production time. In centerless work, on average size pieces, normal allowance for rough grinding can range up to 0.010-inch while 0.001 to 0.002-inch above the high limit should be allowed for finish grinding but here again, if variables are present, some additional allowance may have to be made.

Similarly, stock allowance for internal grinding depends to a large extent upon the bore and length to be finished. For holes up to ½-inch by 1-inch in length, 0.004-inch to 0.008-inch total allowance on diameter is satisfactory; holes up to 1-inch by 4 inches in length, 0.008-inch to 0.012-inch; holes up to 1½-inches by 8 inches in length, 0.012-inch to 0.018-inch; holes up to 5 inches by 8 inches in length, 0.018-inch to 0.025-inch; and holes up to 8 inches by 8 inches in length, 0.025-inch to 0.030-inch. In any case, the smallest and shortest holes use the smallest allowance with the amount increasing to maximum with the largest and longest holes noted. As mentioned previously, unusual conditions or materials, improper centralization of the work or other conditions giving rise to runout, etc., will require some additional allowance.

MATERIALS: There are practically no limitations to the kinds of materials which can be ground. Materials that can be machined by any method can be ground, as well as many that resist finishing by any other method. The scope of grinding thus embraces all of the ferrous metals, including those hardened. All the nonferrous materials such as copper, brass, aluminum, magnesium, bronze, etc. can be readily ground. Nonmetallics such as ceramics, carbon, glass, refractories, plastics, quartz, agate, and sapphire have all been ground on a production basis.

For cast iron, chilled iron, brass, bronze, aluminum, fiber, and other rather low-tensile materials, silicon carbide abrasive wheels are usually employed, while for soft low-carbon steels, annealed malleable iron, and certain high-tensile bronzes, tough regular aluminum oxide abrasive wheels are usually used. On hardened or soft high-carbon steels, high-speed steels, and special alloy cutting tool materials, a highly refined white aluminum oxide abrasive wheel is used.



Grinding Effects May Be Critical

Even the most careful grinding often induces tensile stresses in the ground surfaces of through-hardened steel parts. Stress balance thus disturbed as well as the metallurgical effects of grinding temperature often result in structural change in the surface material and a decrease in impact and fatigue resistance. On the other hand, certain designs are strengthened by the effects of internal grinding. On critical parts which must withstand high stresses, it is thus often advisable to finish grind external portions prior to hardening. Where heat treatment cannot assure parts sufficiently clean and distortion-free, the lightest possible finish grind should be contemplated.

TOLERANCES: Dimensional control of parts being ground has now reached a point where arrangements are available which permit control of size from the work itself to a tolerance of less than 0.0001-inch. It is possible to hold diameters up to 1¼-inch to within 5 millionths in the tool room and 20 millionths on the production line. For production there are a number of automatic sizing devices that will produce holes sized to within plus or minus 0.0001-inch. The fastest method of sizing is done directly from the truing diamond and a hole ¾-inch in diameter by ⅝-inch deep, for instance, can be finished in 15 seconds to plus or minus 0.0005-inch with a surface finish of 10 microinches.

Because of new developments in grinding machine design and grinding technique, parts such as ring gages, bearing races, etc., can be ground to a surface finish of 0.4 to 0.7-microinch. Where high output is desired in general production work, a surface finish

Fig. 29—Left — Proper relieving for face grinding offers maximum benefit. Faces of this casting are held to within 0.003-inch on length and parallelism

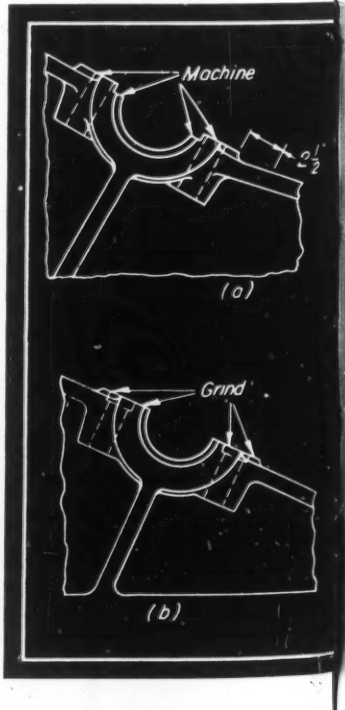


Fig. 30 — Right — Stoker crankshaft bearing bracket (a) redesigned for surface grinding as shown at (b) reduced machining cost and speeded production

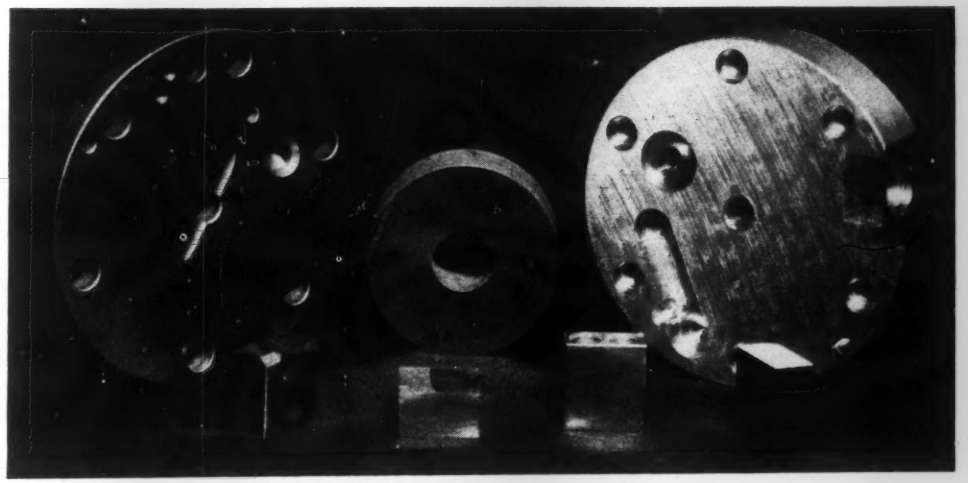


Fig. 31—End plates, roll and blades of refrigeration compressors are surface ground parallel to 0.00015-inch and square within 0.001-inch

of 4 to 5 microinches can be readily held with dimensional tolerances within 0.0001 to 0.0005-inch and roundness within 0.00005-inch.

Centerless grinding will produce parts within plus or minus 0.0001-inch on diameter and parallelism. Roundness is usually within less than 0.000025-inch and where necessary diameter and parallelism can also be held to this figure but at increased cost. Surface finish can be on the order of 1.5 microinches although 5 to 6 or rougher is most practical for economy reasons. Centerless-ground threads can be produced with lead error less than 0.0005-inch per in.

Pitch diameter of center-ground threads can be held to plus or minus 0.0005-inch to plus or minus 0.002-inch depending upon requirements and economy. Roundness can be held to within 0.0005-inch while concentricity of the thread form with the O.D. is well within plus or minus 0.003-inch on the largest sizes. Lead variation, when necessary, can be held to a total of 0.0002-inch per foot but in production 0.0005-inch is a more economical limit.

Reciprocating-table surface grinders will produce surfaces with flatness varying but a few tenths over lengths of 20 feet or more. As a rule large areas, ordinarily given to hand scraping, can be finished to within 0.0003-inch or less. Parts finished on rotary-table machines can be held to flatness of 0.0002-inch to 0.00005-inch, parallelism of 0.0004-inch to 0.00005-inch, and length to plus or minus 0.0002-inch, *Fig.* 31.

Extreme Flatness Difficult To Obtain

Flatness measured in light bands can be produced on rotary-table, vertical-spindle surface grinders but not in high production; the grinding cannot be hurried. Metal removal must be slow, wheel pressure light, and wheel face sharp. Best procedure is to grind to within 0.005-inch or less of final size and then finish grind. Material must be free from stresses and the section sturdy to resist distortion.

Surface finish as a rule is dependent to a certain extent upon the material being ground, hardness of the material being a deciding factor. Materials such as hardened steel can be ground to a finish of 2 microinches or less in regular production while on softer materials, a finish of 10 microinches may be difficult to obtain. An approximate idea as to practical surface finish for various materials can be had from the following list:

Hardened Steel	2 microinches
Soft Steel	5 microinches
Cast Iron	5 microinches
Brass	12 microinches
Aluminum	15 microinches

As is evident, it is easier to produce a fine finish on the harder materials and in the case of iron castings the limit is primarily that which reveals the grain structure, and beyond this the finish cannot be improved.

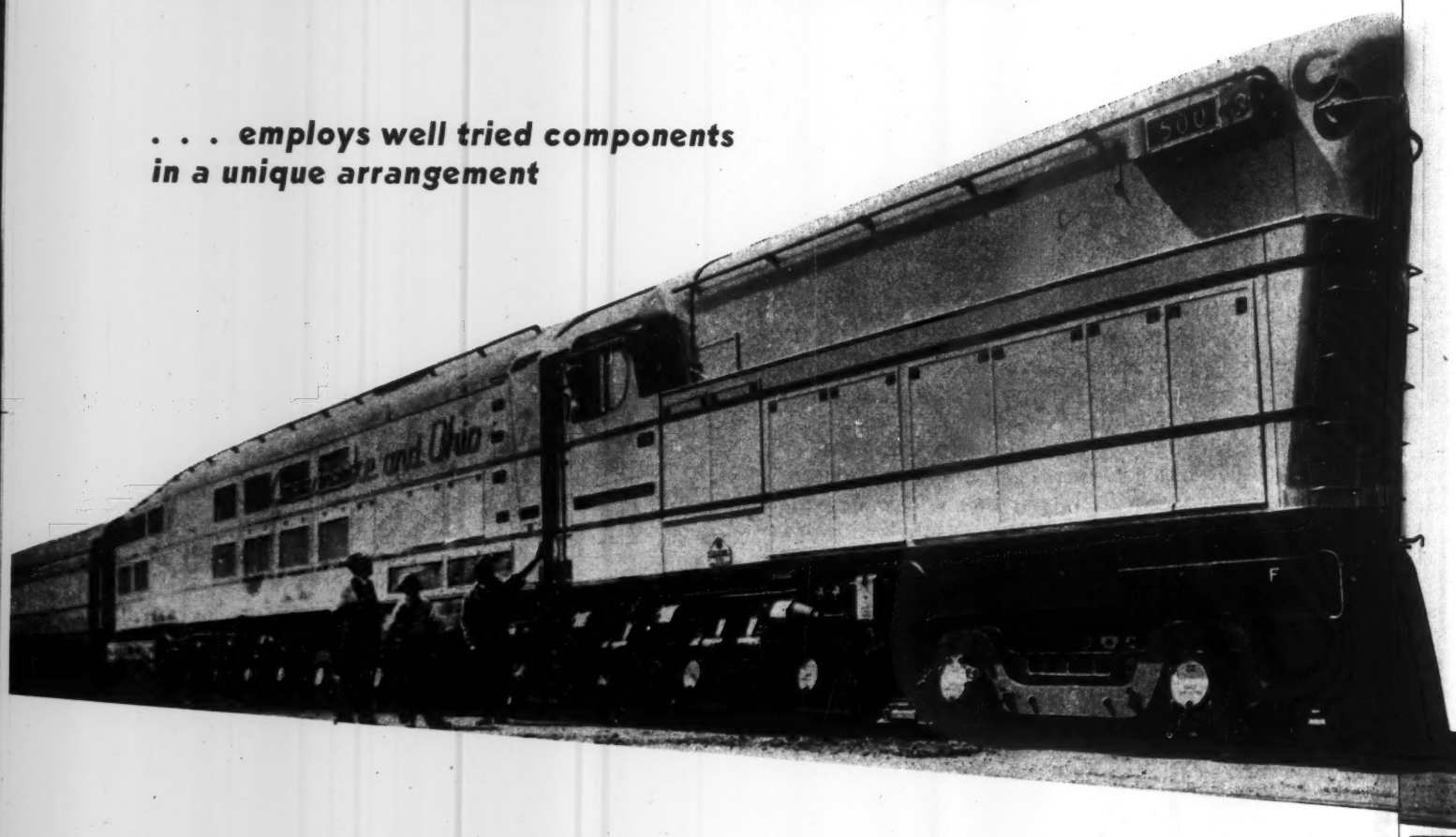
Tolerances as well as surface finish naturally should be no closer than actual function or design necessitates to assure maximum production at lowest cost. The roughest acceptable finish should always be specified and where surface finish and pattern are critical design characteristics, honing, lapping or Superfinishing should be considered. Finish specifications, where important, should not be general or contain loose phraseology capable of gross misinterpretation. Functional requirements for a specific part should be closely analyzed—it is possible to have too perfect a surface. Table ways, for instance, can be flat to the point that lubrication fails to separate the moving parts. Characteristic range of surface roughness figures for machine parts widely used will help judge as to what constitutes a practical finish.

Collaboration of the following organizations in the preparation of this article is acknowledged with much appreciation:

Abrasive Machine Tool Co. ..... East Providence, R. I.
American Engineering Co. (*Figs.* 29 & 30) ..... Philadelphia, Pa.
Blanchard Machine Co. (*Fig.* 31) ..... Cambridge, Mass.
Brown & Sharpe Mfg. Co. ..... Providence, R. I.
Bryant Chucking Grinder Co. (*Figs.* 19, 20, 23 & 24) ..... Springfield, Vt.
Carborundum Co. ..... Niagara Falls, N. Y.
Cincinnati Grinders Inc. (*Fig.* 28) ..... Cincinnati, Ohio
Ex-Cell-O Corp. ..... Detroit, Mich.
Gear Grinding Machine Co. ..... Detroit, Mich.
Giddings & Lewis Machine Tool Co. ..... Fond DuLac, Wis.
Hanchett Mfg. Co. ..... Big Rapids, Mich.
Heald Machine Co. ..... Worcester, Mass.
Landis Tool Co. ..... Waynesboro, Pa.
Mattison Machine Works ..... Rockford, Ill.
Norton Co. ..... Worcester, Mass.
Sheffield Corp. ..... Dayton, Ohio
Thompson Grinder Co. ..... Springfield, Ohio

Turbine-Electric Locomotive

. . . employs well tried components in a unique arrangement



CURRENTLY in partial eclipse, the steam locomotive may stage a comeback and re-establish itself as a popular favorite with the railroads. A design with promising characteristics is the Baldwin-Westinghouse steam turbine-electric locomotive, *Fig.* 1, recently completed for the Chesapeake & Ohio railway.

Ability to burn coal rather than oil gives this type of engine the edge over the diesel for railroads such as the C & O which traverse coal regions and depend on coal carrying for their principal revenue. Use of a turbine in place of reciprocating engines improves power and economy at the higher speeds as well as giving smooth starting and free-

Fig. 1 — Top — New Baldwin-Westinghouse coal-burning steam turbine-electric locomotive for high-speed passenger service

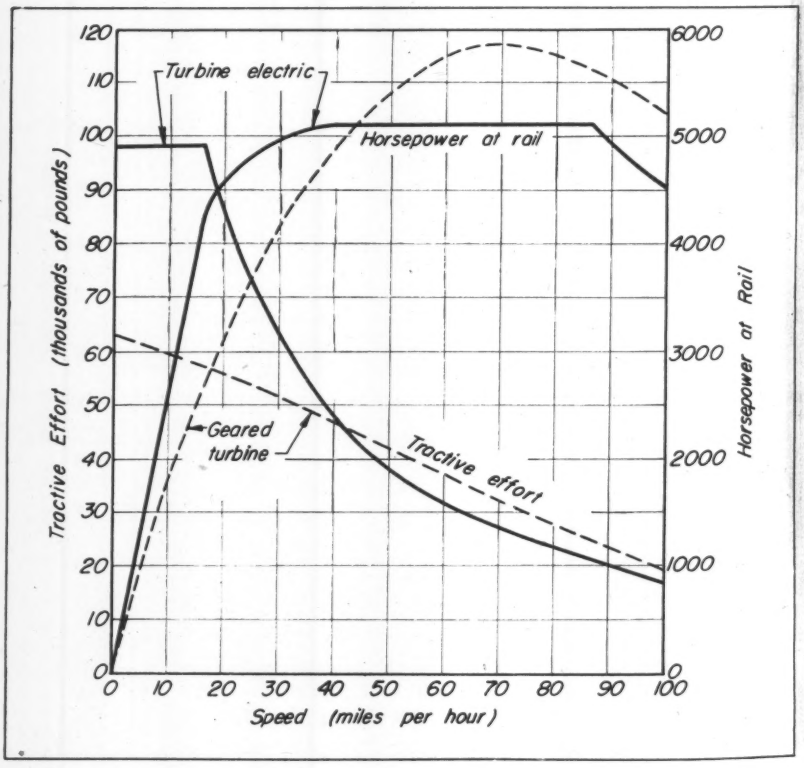


Fig. 2—Right—Performances of geared and electric turbine locomotives compared

dom from pounding on the rails. Electric drive gives starting and low-speed performance similar to that of the diesel-electric and much better than that of either the reciprocating engine or geared steam turbine, *Fig.* 2.

Although the arrangement of the new locomotive is novel, no new untried elements are incorporated in its design. Steam is generated in a conventional stoker-fired fire-tube boiler. The turbine is essentially the same as that employed in the geared-turbine locomotive built for the Pennsylvania railroad (see "Steam Turbines Drive New Locomotive," MACHINE DESIGN, April, 1945, Page 141). Transmission of power from the turbine to the wheels is by direct-current electric drive similar to that employed in diesel-electric engines. Between the front of the locomotive, *Fig.* 1, and the cab is the coal bunker, with capacity for 30 tons. Behind the cab is the boiler, beyond which is the turbine-electric power plant. A separate water tender behind the locomotive proper has capacity for 25,000 gallons. Leading particulars of the locomotive and its equipment are listed in TABLE I.

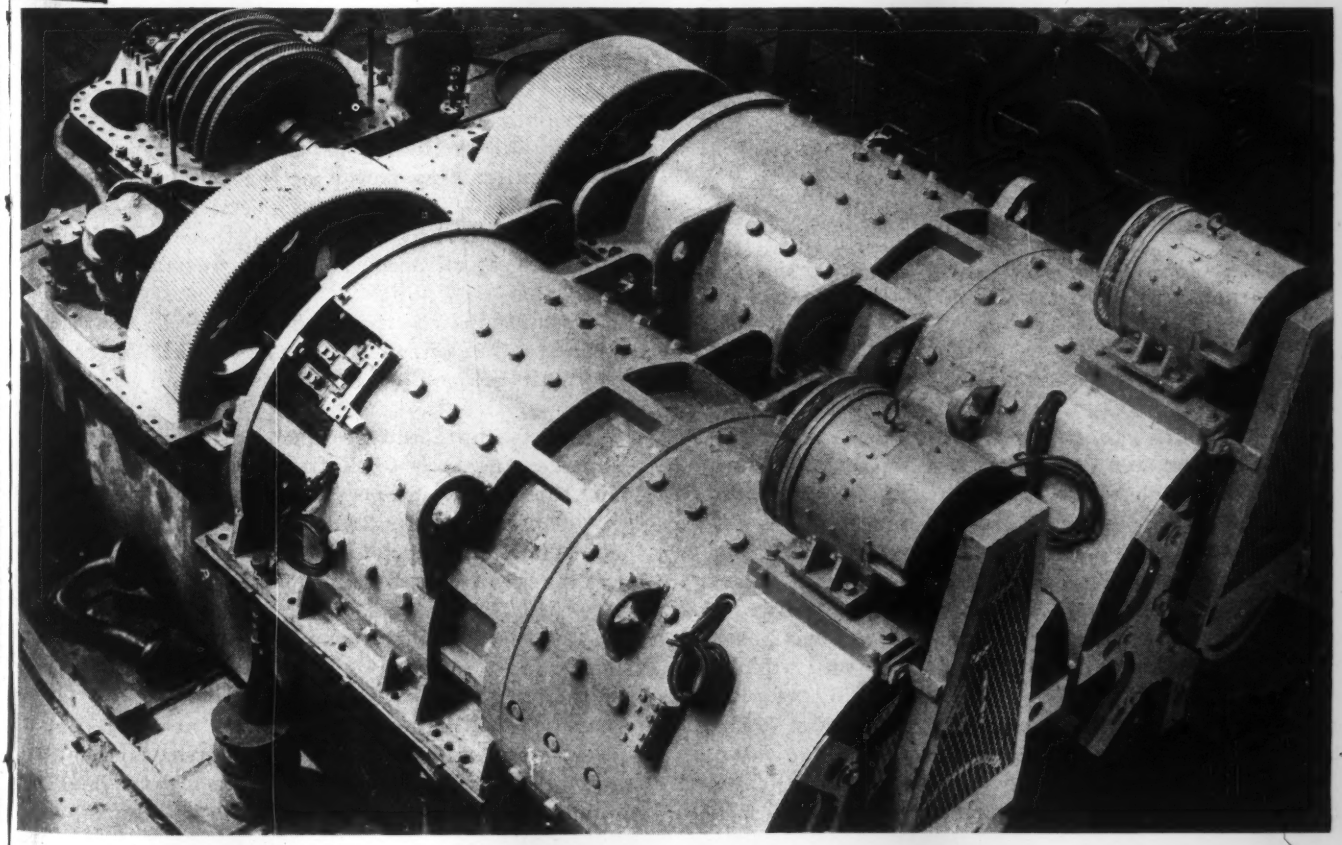
A single 6000-hp turbine drives the two main generators through reduction gears, *Fig.* 3. Of the impulse type, the turbine has one velocity-compounded stage followed by four single-row pressure stages, *Fig.* 4. Steam flow is controlled by a governor-operated series of seven valves contained in a steam chest cast integral with the turbine cover. Each valve admits steam to one of seven groups of nozzles at the entrance to the high-pressure stage. As power demand changes, the valves are opened or closed in sequence, thus minimizing throttling loss at any opening.

Turbine and Traction Motor Gears

Turbine reduction gears consist of a single high-speed 45-tooth pinion meshing with two 272-tooth gears, each of which is coupled to a double-armature d-c generator. The gears are 6 diametral pitch and have a 9-degree helix angle. Thrust bearings are provided at the low-pressure end of the turbine shaft and on each gear shaft. Traction motors drive the 40-inch wheels through spur gears of 2 diametral pitch having 24 and 55 teeth, respectively, in the pinions and gears.

Because of space and weight restrictions it was not practical to build the locomotive frame rigid enough to maintain satisfactory alignment of rotating parts in the propulsion unit, *Fig.* 3. The unit is therefore built as a self-contained assembly supported at three points—two trunnions at the forward corners and a rubber supporting pad between the generators. With this arrangement no frame deflections are transmitted to the unit. To prove the adequacy of the

Fig. 3—Below—Power plant showing single 6000-hp turbine and twin generators



design a one-quarter scale model was built and tested prior to construction of the actual unit (see "Model Analysis Aids Designer," MACHINE DESIGN, Jan. 1948, Page 120).

Generators and traction motors are of types which have proved successful in diesel-electric service. Because the locomotive burns coal, special precautions have been taken to insure a supply of smoke and steam-free ventilating air to the electrical equipment. All air for the blowers is taken into the locomotive forward of the stack, and a bulkhead separates the blowers in the rear compartment from the generators so that recirculation of air is negligible. Removable doors separate the electrical control equipment from the heated air discharged by the generators.

Speed control differs somewhat in principle from that employed with diesel-electric drive, part of the acceleration being obtained by varying the field strength of the generators and part by speed control of the turbine down to about 60 per cent of full speed. The master controller has two handles—one for speed and one for direction. With the speed handle in "Idle" position, as when standing at a station, the turbine speed is approximately 3500 rpm. Moving the controller in succession to eleven speed positions progressively increases the excitation of the generators to the maximum and applies power to the traction motors. At the same time turbine speed increases to about 4500 rpm (75 per cent speed). Further movement of the controller brings the turbine up to its full speed.

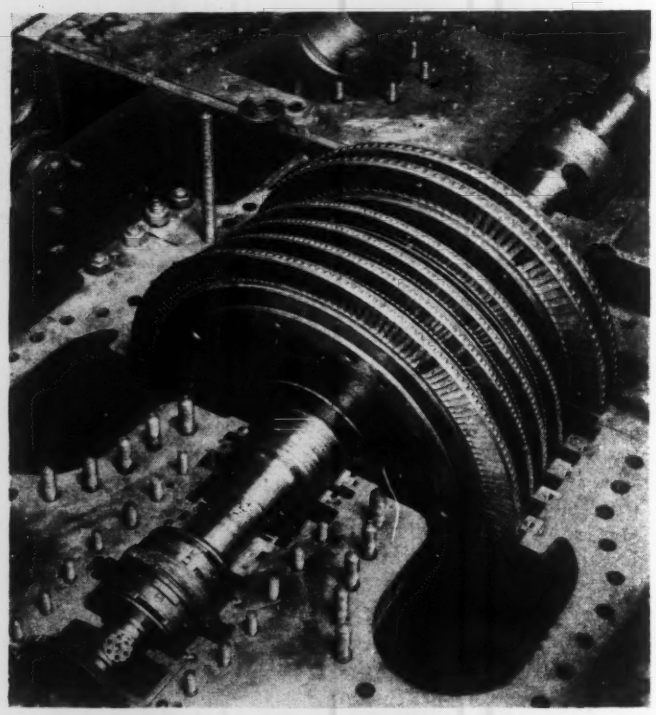


Fig. 4—Propulsion turbine with cover removed, showing segmental type thrust bearing at low-pressure end

Intended for hauling new high-speed passenger trains between Washington and Cincinnati, the new locomotives will be required to traverse heavy mountain territory in the eastern portion and level territory in the west over which speeds up to 100 mph are required. However, the performance characteristics are equally well suited to freight operations, particularly where large capacities are required. The lower limit of capacity to which the turbine locomotive is likely to be built is 3000 to 4000 hp.

Compared with the geared-turbine drive the electric drive is considerably heavier because of the addition of generators, motors and control equipment. On the other hand, the electric-drive turbine runs continuously in the same direction, thus eliminating the need for a separate turbine and clutch for reverse operation. It also results in greatly reduced steam consumption at starting and low speeds. The torque conversion which the electric drive provides greatly increases the flexibility of the locomotive and furnishes high starting power, as the performance chart, *Fig.* 2, shows. Although the electrical losses reduce the tractive effort at high speeds, there is still ample power to meet all needs at any permissible operating speed.

TABLE I

Particulars of Turbine-Electric Locomotive

General:	
Total wheelbase, ft	140
Total loaded weight, lb	1,194,800
Weight on drivers, lb	580,000
Tractive effort at starting, lb	98,000
Tractive effort, continuous, at 40 mph, lb	48,000
Top speed, mph	100
Boiler:	
Working pressure, psi	310
Capacity, lb steam per hour	85,000
Turbine:	
Steam pressure at inlet, psi	290
Steam temperature at inlet, ° F	750
Exhaust pressure (noncondensing)	Atmospheric
Horsepower	6,000
Speed, rpm	6,000
Generators (2):	
Volts, continuous per armature	568
Kilowatts, continuous per armature	1,000
Speed, rpm	1,000
Traction Motors (8):	
Volts	568
Horsepower at shaft, continuous	620
Speed, rpm	720
Auxiliary Generators (2):	
Volts	75
Kilowatts, each	9

It is anticipated that the turbine-electric steam locomotive will introduce no new maintenance problems, inasmuch as all components are well tried. Servicements of the conventional locomotive will be met by existing facilities. Electrical equipment maintenance corresponds to that on diesel-electric engines. There are no slow-speed reciprocating parts with their own peculiar maintenance problems, while the turbine itself should add little to the servicing problem; the geared turbine locomotive already in service for the Pennsylvania railroad has operated for at least 2½ years with complete absence of turbine trouble.

Although the new C & O locomotive uses a conventional boiler, further developments are expected in the direction of higher steam pressures and temperatures, which the turbine can utilize to excellent advantage, with further improvements in economy.

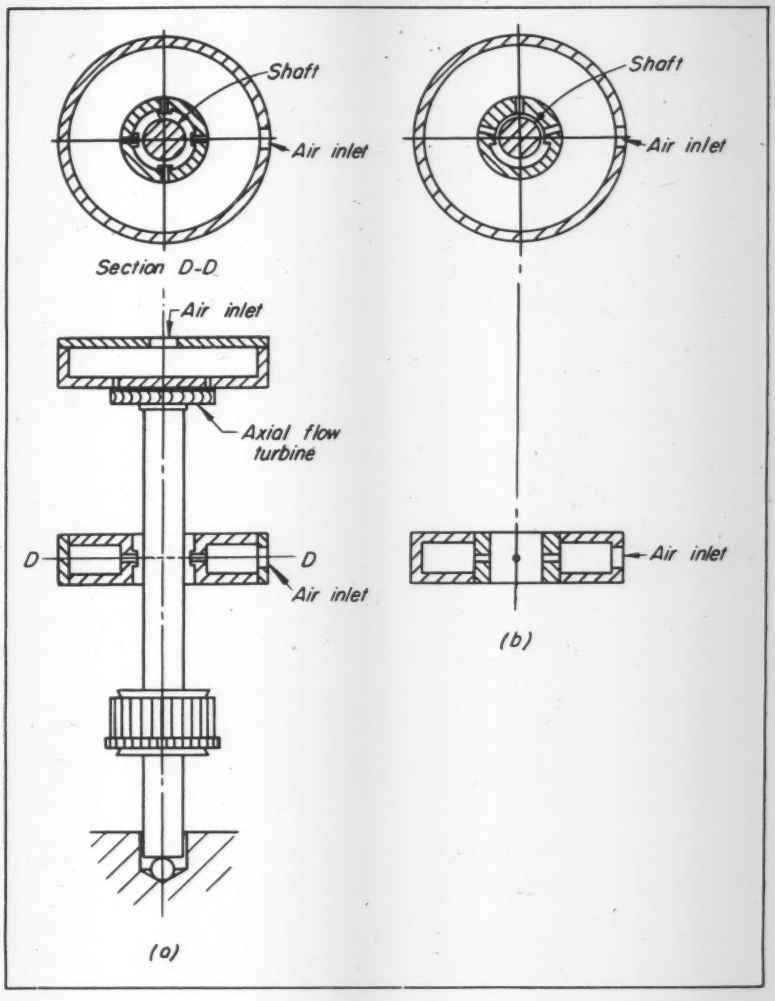


Fig. 1—First design of air-driven air bearing spinner (a) would not center on ball and even after modification (b) was axially unstable

By L. W. Wightman
General Electric Co.
Ft. Wayne, Ind.

Air-Driven Spinners

. . . for testing fast-rotating machine components up to bursting speeds pose mysterious design problems which are discussed in this article

MORE horsepower for less weight in aircraft motors requires the highest shaft speeds that the rotating parts can stand. To aid in the development of suitable parts, particularly commutators, test equipment was needed that would spin rotors up to speeds which would insure an adequate safety factor over the maximum speeds expected in service.

Available means for spinning commutators included V-belt and flat belt grinder heads which, however, were limited to 30,000 and 40,000 rpm, respectively, due to loss of belt contact with the pulleys at high speed.

A promising development was a direct drive using a high-frequency motor. The motor was flexibly mounted with its output shaft vertical and down. A commutator hung on this shaft was supposed to spin around its own center of gravity so that commutator unbalance would not affect the drive motor. After many unsuccessful trial runs the following simple rules of nature were found to be still in effect:

The finer the wire on which the spinning was done, the lower was the critical speed at which the commutator spun about its own center of gravity. However, as soon as the periphery of the wire crossed the center of rotation of the system, centrifugal force bowed the wire. When the wire was retained as in a tube, its performance was the same as if it had been shortened.

When a short wire or a flexible shaft (same as a heavy wire) was used, their stiffness raised the critical speed so much that any unbalance or misalignment would make the commutator rotate in a larger and larger circle, and the short wire or semi-flexible shaft would bend before the critical speed

was reached at which the commutator would rotate around its own center of gravity. However, pancake-shaped objects such as impellers can be spun in this manner because of the inherent gyroscopic stability which they possess.

Inasmuch as an air-driven turbine was being used as the drive for a super-charger impeller spin test, air drive was next considered. Cone-shaped air-driven spinners were described in a paper by J. W. Beams of the University of Virginia. With this as a background, a program was launched to develop an air-driven air bearing commutator spinner. It was realized that if such a spinner could be developed, it would have the following advantages:

a. High-speed direct turbine drive
b. Variable speed readily obtainable by throttling
c. Large air bearing clearance to allow rotating parts to spin around their own center of gravity.

The only disadvantage was that no one knew how to make such a spinner.

First try at making an air-driven, air bearing commutator spinner is shown schematically in *Fig.* 1*a*. The shaft did not center itself on the ball as it should have, and the upper bearing did not work well. However, if the bearings had functioned as expected it would not have helped the operation, because every time the spinner got up to a fair speed the rotating part jumped straight up and the turbine wheel started grinding against the nozzle box. Bernoulli's principle worked overtime on the turbine wheel, but it would not even work half time on the upper bearing. After the space between the turbine wheel and the nozzle box was properly vented, the top bearing, *Fig.* 1*b*, continued to forcibly eject the shaft now and then and, concave or convex, the bottom end of the shaft just would not stay on top of the ball.

The next spinner, *Fig.* 2*a*, was an adaptation of the spinner described in Mr. Beams' article. With this spinner, much experience was gained as to what constitutes stability. Under some conditions the rotor jumped straight up and down instead of turning. Under other conditions it would totter from side to side. Then sometimes the rotor would start up well only to go into a gear-like motion and roll round and round the stator to a stand still. Most of these phenomena occurred where the center of gravity of the revolving mass was high. Unloaded and with the stator cushion mounted, the stability was quite good.

Stabilizer Cut Down Speed

A gyroscopic stabilizer was tried, as shown in *Fig.* 2*b*. This led to the idea of using the cone as an air bearing only, and a series of jets tangent to the periphery of the gyroscopic stabilizer as the driving force. The spinner worked fairly well except for speed. There was too much air friction loss before the air left the peripheral jets. Then, too, the jets were at a large radius which was a disadvantage in producing high rotational speed.

The third spinner, *Fig.* 3, was built with a positive determination to get stability by brute force. Here was a design where the rotor could not go anywhere

Fig. 2—Spinner with conical turbine wheel (a) was stable only when unloaded. When modified by addition of a gyroscopic stabilizer and use of reaction air jets (b) the stability was improved but speed was inadequate

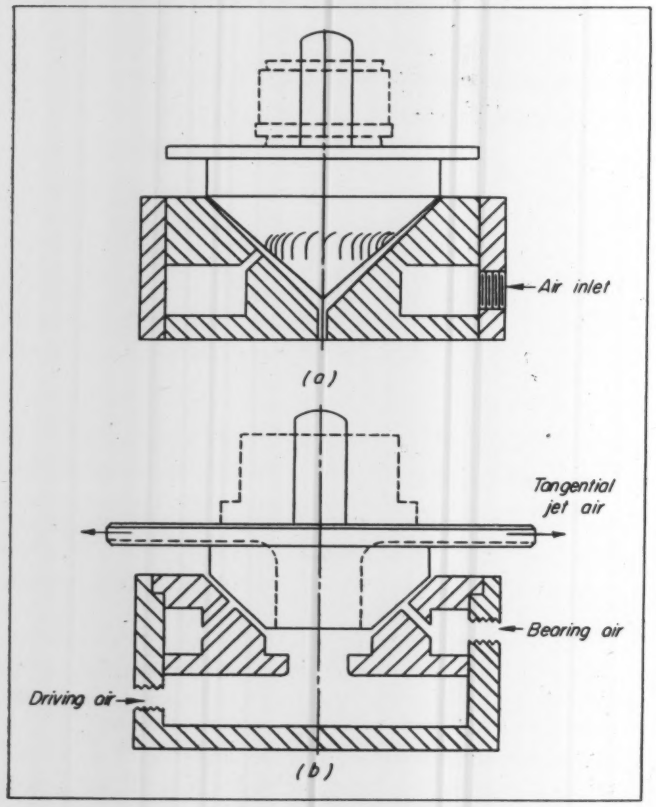
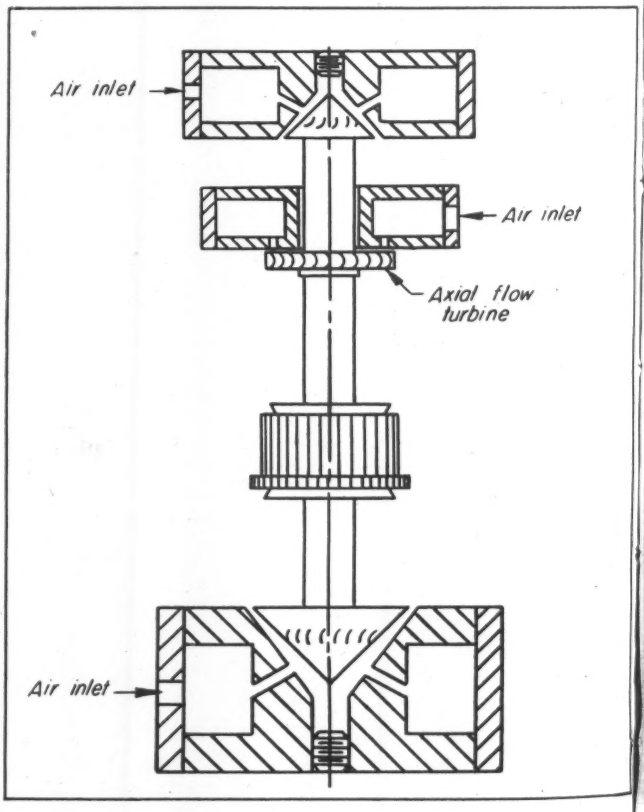


Fig. 3—Spinner with two conical air bearings could not be made to rotate under any circumstances



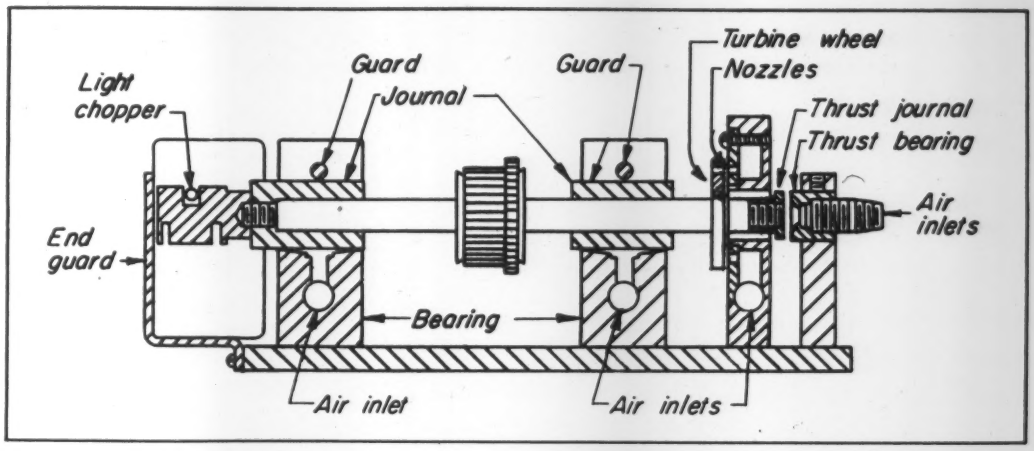
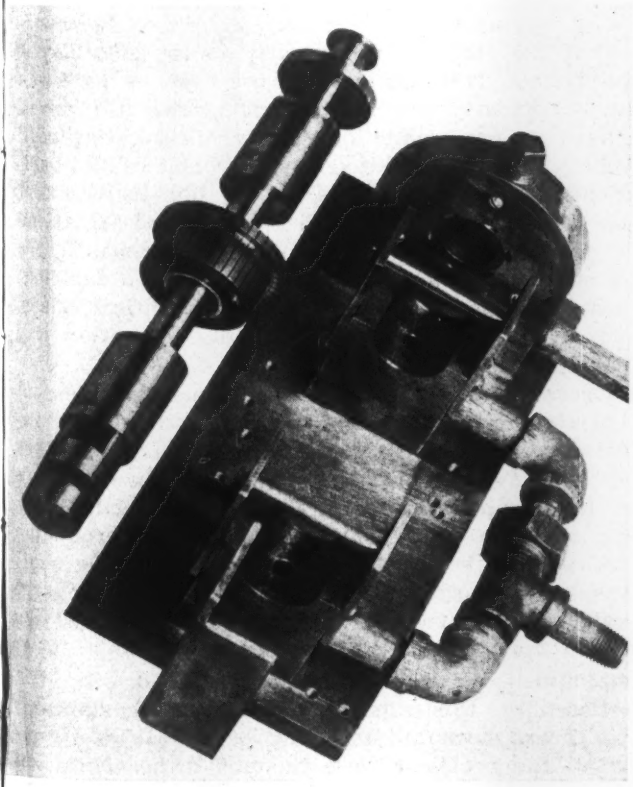


Fig. 4—Horizontal spinner could not be loaded fast enough to spin hot commutators but was successful for certain purposes

but around and around. Of course, it could not be readily loaded and unloaded, but that would come later. After the spinner was built and set up for test, all precautions for high-speed testing were taken and the air was turned on. Instead of turning, the rotor jumped straight up and down accompanied by a loud noise. The top cone stator was raised, it was lowered, it was connected to a separate air source, the whole machine was leveled, holes were drilled and holes were plugged, but number three spinner never did do anything but make a noise.

After these experiences, a horizontal position was thought to have advantages for spinning, and the spinner shown in *Fig.* 4 was built. This spinner, unlike any of its predecessors, was completely stable the first time it was run. It required two air lines,

Fig. 5—Disassembled view of the horizontal spinner of Fig. 4, showing safety bars over tops of journals



one for the two horizontal bearings and the thrust bearings, and one for the turbine. When the turbine air is not turned on, the rotor will float quite stably in space. If the base is not perfectly horizontal, the rotor will turn slowly as if rolling down hill.

Bearings were made from solid steel blocks, a special cutter being designed to get the shape shown. The bearing to journal clearance was designed to be 0.032-inch all around, and the bearing shape was such that a fairly constant air flow area was maintained from the hole in the bottom of the bearing to the 0.032-inch clearance exhaust. With such a large amount of clearance a large amount of air was used, but this was felt necessary to allow for a relatively large amount of unbalance.

The thrust bearing as shown was found to be extremely stable if enough air was used. However, there was a critical small amount of air at which oscillations, if once started, would increase in magnitude until the rotor was driven off the bearings. With an increase in the amount of air, any hand-started oscillations rapidly decreased in amplitude to zero.

The turbine drive was not designed for extreme efficiency, since rough calculations showed that 70 psi shop air pressure should drive a 3-inch diameter commutator at about 100,000 rpm. The only loss was thought to be air friction, since the bearing loss was believed to be negligible.

Speed Measured Optically

On the end opposite the thrust bearing, a light chopper was attached, so that the speed could be measured. The light chopper consisted of a flat space in the periphery of a round cylinder. Through the flat space a strong beam of light was focused on a photoelectric cell. Then as the cylinder turned, the light beam was chopped off, except when the flat space came around. Hence, for each revolution, the photoelectric cell would receive a flash of light. The number of these flashes per minute was at first indicated by means of a cathode ray tube. But, because of the difficulty of this method, an instrument was developed by the laboratory which indicated the flashes in the form of revolutions per minute on a dial face meter.

The horizontal spinner was set up with a 3-inch

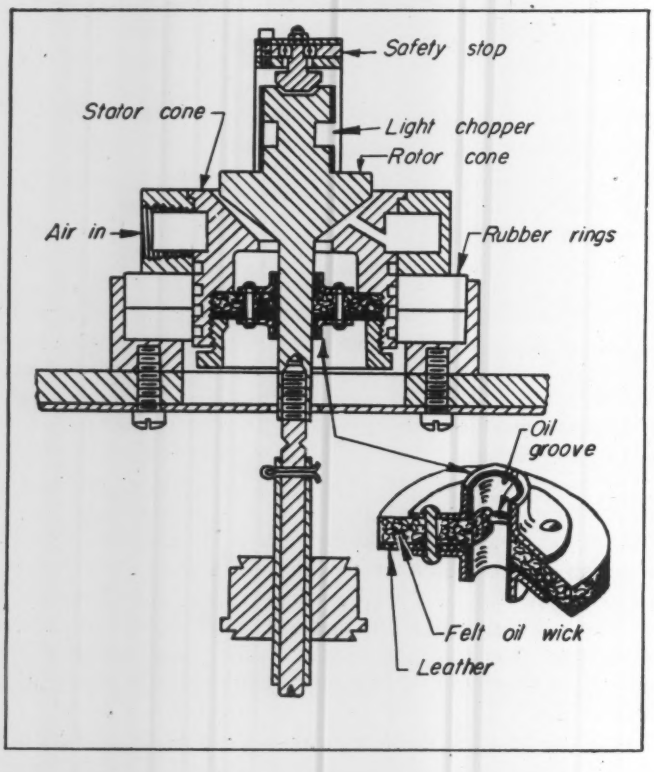
diameter solid steel mock-up commutator to determine how fast it would run. The set-up was enclosed in a box of double thickness ¼-inch steel boiler plate as a safety precaution, and the test observed through a small hole in the end of the box. As speed was increased slowly, the observer watched for any irregularity. At 69,000 rpm there was a loud crash followed by a continuous air-hammer-like noise which lasted several seconds. The observer explained that nothing happened until the instant everything in the box seemed to disappear and the light went out. The shaft was twisted and broken in two places; in fact, every part of the spinner was bent, twisted or broken. The sides of the box were bulged but unbroken.

Construction Error Caused Failure

Later the cause of the blow-up was discovered. The thrust bearing journal had come unscrewed and forced the spinner off its bearings. A right-hand thread had been used instead of the left-hand thread called for on the drawings.

An exact duplicate of the first horizontal spinner was built, except that the thrust journal was screwed on with a left-hand thread. An end stop and safety bars over the journals were also incorporated, *Fig.* 5. While the horizontal spinner was successful in a way, it could not be loaded fast enough to spin hot commutators. However, it has been used by the laboratory to measure the bar to bar variation in expansion or throw-out at high speeds. Absolutely vibrationless rotation is a prerequisite for such a measurement, so that bearings of a fixed type can not be used. With such bearings an object could not spin about its center of gravity and would therefore vibrate excessively at criticals.

Fig. 6—Vertical air spinner designed for fast loading was successful under certain conditions



Because of the fast loading requirement and the desire to spin commutators on their checking arbors, another vertical spinner was developed. This time the commutator was hung below the spinner cone as shown in *Fig.* 6. The reasons for this arrangement were to maintain a low center of gravity and to make fast loading easier. With this arrangement, the natural place for the light chopper was on top of the spinner cone.

Now with the commutator hung below the spinner cone, there arose the problem of an air seal around the vertical shaft. For this a floating bearing was used as shown. A floating sleeve bearing was thought not to have the high speed difficulties that a supporting sleeve bearing would have. This bearing was mounted on a leather diaphragm and lubricated by the oiled felt washer above the leather. The first bearing was of hardened steel. This was thought to be satisfactory, since it would have adequate lubrication and would be unloaded. However, the steel bearing froze time and again. A bronze bearing was made to replace it and no more trouble was experienced.

Floating Bearing Improved Operation

The floating bearing undoubtedly acted somewhat as a vibration damper as well as an air seal. This apparently added greatly to the stability of the spinner, although it obviously caused additional friction loss. The spinner would run without the floating bearing, but it would not operate with as much stability or as fast.

Stationary part of the spinner was similar to the stationary part of the first cone type spinner, except it was made as light as possible and mounted on sponge rubber rings. Light weight and flexible mounting of the stator added greatly to the stability of the system. This was because the rotating part was not particularly well balanced and since it revolved around its own center of gravity, the rotating cone wobbled in the stator cone. This wobble caused variations in the thickness of the air film between the cones. The air film was like a spring and variations in its thickness were like forced vibrations. Where the stator cone was free to move but with damping, these vibrations were damped at their critical values. Where the stator was held rigidly, operation was impossible.

Operation of this spinner was successful except that there were no provisions for a commutator explosion. A combination shear plate and notch as shown in *Fig.* 6 was tried. Supposedly the unbalance of the commutator when it exploded would cause the shaft to break at the notch, thus protecting the rest of the spinner. However, when the shaft was notched satisfactorily for protection, a large scale critical vibration occurred between 19,000 and 21,000 rpm which the spinner was unable to go through.

Based on this experience, the spinner shown in *Fig.* 7 was developed and built for actual factory use, as all the problems were thought to be solved. It

was similar to the previous spinner (*Fig.* 6) except that it was slightly larger and a thin hollow cylinder was hung from the vertical shaft extending below the spinning cone. This hollow cylinder was made to house various size commutators mounted on arbors all of which were made the same length. The top end of each arbor was splined and centered to fit a driving spline and center in the top of the hollow cylinder. The bottom end of each arbor was held on a center which was spring mounted to the cap on the bottom of the cylinder with a bayonet type fitting. Thus, the spring in the bottom center held the arbor against the top center while the spline drove it. The space between the various diameter commutators and the inside of the hollow cylinder was filled with various thickness sleeves. Always the sleeve left a thin gap around the commutator periphery so that the commutator could explode but the bars could not move far enough to throw the spinner enough out of balance to cause any trouble.

Vibration Prevented High Speed

When the new spinner, *Fig.* 7, was built, preliminary tests proved very disheartening. The spinner would start in a normal manner but, at a relatively slow speed, a low frequency vibration would develop. All the air power was absorbed in this vibration and no increase in speed could be obtained. The basic parts of the spinner were removed and set up on an open test stand where visual observation could be made. Here the leather and felt diaphragm, which held the floating bearing, was found to be vibrating with a large amplitude.

The small increase in the size of this spinner over the previous one was evidently just enough to allow a critical reaction to take place between the diaphragm and the rotor of the spinner. They seemed to be blown apart and then sucked together successively. Since the diaphragm was not as rigid as that on the previous unit, it was stiffened with washers on either side. However, no reasonable amount of stiffening would stop the vibration. The vibration frequency increased only slightly as the stiffness was increased. Loosening the diaphragm was also tried but without success. The cause of this difference between the two similar units (*Figs.* 6 and 7) is not known by the author or anyone he has consulted on the subject.

Vibration Eliminated by Jets

Since the vibration could not be eliminated by stiffening the diaphragm, jets were built into the diaphragm to reduce the exciting force of the vibration and to dampen it. The jet hole diameters were increased in small steps until the vibration was entirely eliminated. Air was exhausted through the jets at slow speeds and during acceleration, but at high constant speeds air was drawn in through the jets.

The new spinner was then set up in production and operated successfully for several months. Then one day it developed another complex. It began to vibrate and to wobble excessively at low speed. After

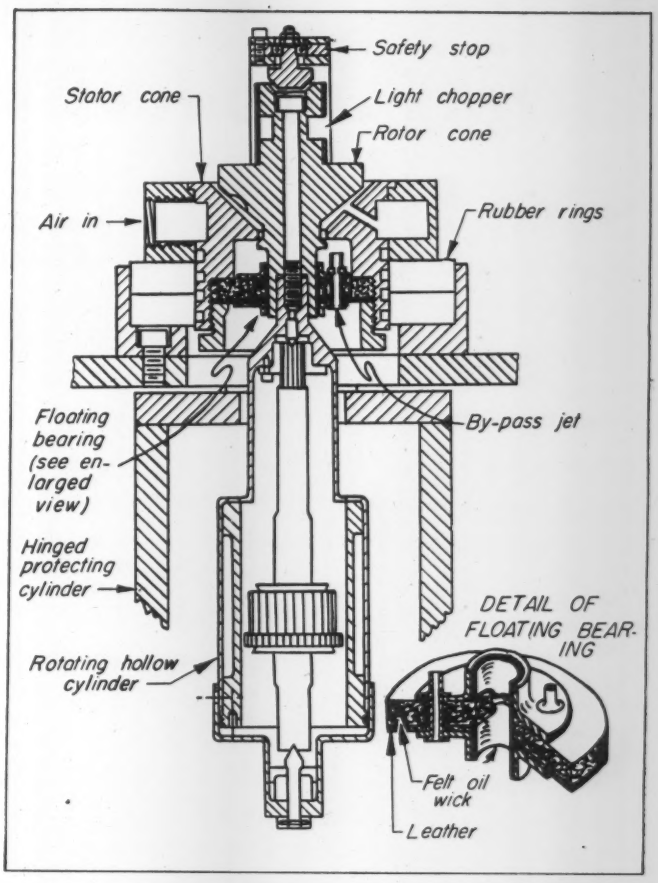


Fig. 7—Production version of the vertical spinner in Fig. 6 was slightly larger and incorporated a housing surrounding the commutator being tested. Drag of housing limited the top speed with air at line pressure

much investigation, the trouble was discovered. The spring in the mounting of the bottom center had partially failed. It would still push the center up, but it would not hold the arbor rigidly against the top center. This slight looseness of the commutator and arbor in the cylinder had caused the trouble. Once the assembly was made rigid again there was no more energy-absorbing vibration. The necessity for maximum rigidity had been considered previously. Its attainment in some of the previous designs was accidental.

On a shop air circuit of about 60 psi pressure the new spinner, *Fig.* 7, will only do a little over 30,000 rpm, because of the large windage drag on the cylinder. For higher speeds greater pressure would be required or the design modified to utilize a greater quantity of air. The vertical spinner shown in *Fig.* 6 has lately been adapted to spin very small commutators and complete armatures. The small commutators cause such a small windage loss that tests have been run at speeds of well over 60,000 rpm.

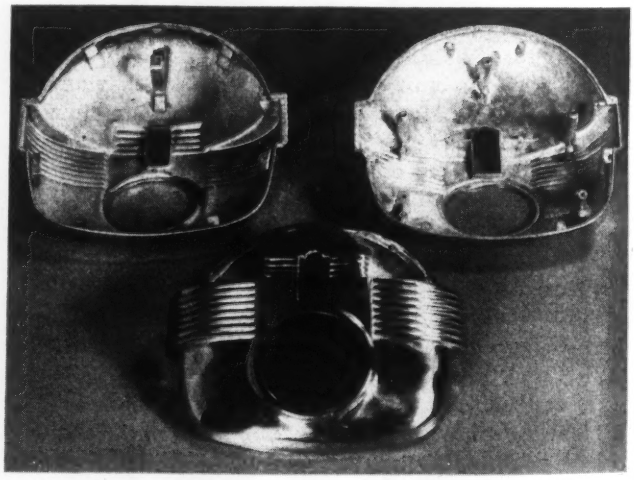
Vertical spinners of the type described here should be adaptable for spinning any small object as they are simple and economical. As the size of the spinner increases, however, a prohibitive amount of air is soon required. The production spinner, *Fig.* 7, finally turned out to be simpler, less expensive, more reliable and easier to operate than a grinder head spinner.

Cutting Production Costs? Watch Design Details!

By A. F. Murray
Works Manager
Electrolux Corp.
Old Greenwich, Conn.

Fig. 1—Above—Original upholstery cleaner diecasting, left, and redesign for economical production, right

Fig. 2—Below—Use of diecasting, upper right, eliminated all but two processing operations required to fabricate original stamped cover, left



A SMOOTHLY operating, low-cost, efficient, profitable production line is not only a matter of capital equipment (buildings, machinery and tools) manned by skilled and cooperative personnel, but is dependent on little details in design of product, production tooling and materials handling to a greater degree than is usually realized.

Even if you know and practice all the principles attendant to good designing for production, the perfect design will not automatically result. The designer or production man is not an Olympian Jove from whose brow Athena, the all-wise, could spring full grown. Evolution, necessity and the combination of ideas from many individuals are required in the continual development of any product detail.

Knowledge of the skills and equipment available to the producing factory, the time available before start of production, maximum daily production, total quantity to be produced, and life of design are also tremendously important and must all be carefully weighed. An entire article could easily be devoted to these points but only a few of the principles applying to the details of design will be dealt with herein.

First, in design of the product itself, the greater the volume, the more complete must be the specifications and control of the materials entering each stage of the production. Castings, sheet material and so forth must be more uniform in dimensions and in machining or forming quality. Fabrication must be to closer tolerances, with tooling more and more foolproof and less susceptible to breakdown. Material handling must provide more and more direct flow so that errors may be caught without large

IMPORTANCE of design details in volume production is emphasized in this article based on a paper presented at the recent ASME annual meeting

quantities of defectives in stores or between operations. Also, equipment and organization must be flexible to minimize results of such errors, breakdowns or changes which may occur.

Castings should be dimensioned and tooled with due regard to foundry or die-casting practice, so that variations caused by parting lines and shifting cores will not cause offcenter cover plates or bolt boss drilling, thick and thin walls, etc. As an example *Fig.* 1 shows a before and after change on an upholstery cleaner diecasting. To the casual observer there is no difference. A careful examination, however, will reveal that the bottom lip of one has been thickened sufficiently to raise it above the vent slot, so that under no circumstances will there be any sharp edges around this slot requiring extra work to remove. The character of the trademark lines has been changed to include a slight radius in the bottom corners of all the letters and lines. This makes the buffing compound wash out in the cleaning operation without the necessity of using a scrubbing brush to clean the corners. In the revised design, the trademark was raised slightly with relation to the lip, so that no part of the circle would be close to the blending radius between the main body and the lip. These apparently trivial changes made an actual difference of four cents each in the finishing cost of this item. At our present production this means a saving of several thousand dollars per month.

It is of primary importance in mass production to reduce to a minimum the number of directions from which a casting or other part must be machined. Frequently it is possible to put hand-hole plates, setscrews or drain plugs in the same plane as major machining and make it unnecessary to turn over the jig or part or to machine in a special setup. Likewise, reduction in the number of parts or processing operations or both may yield important cost reductions as in the case of the front cover of the Electrolux vacuum cleaner, *Fig.* 2. Without changing the outside appearance from that shown in the lower figure, a metal stamping—requiring 16 press operations on the major stamping, nine metal clips of five types spot welded in five operations, and one drilling operation—was changed to a one-piece die casting with cast-in holes for drive screws, so that no operations except polishing and buffing were required.

Production Problems Eliminated

Redesign of several parts of the filter housing of the vacuum cleaner is shown in *Fig.* 3. The design required a crossbar to protect the louver doors covering the hose opening. The parts on the right show the original design in which the crossbar was a separate piece. The filter housing had its edge rolled over, leaving two spots for clinching the bars in place after all polishing and plating were applied. This clinching operation gave considerable punishment to the nickel and chrome plating, and frequently caused rejects due to peeling or cracking of the plated surface at this severe bend.

The louver frame had always been made from the salvaged center of another part of the unit. It con-

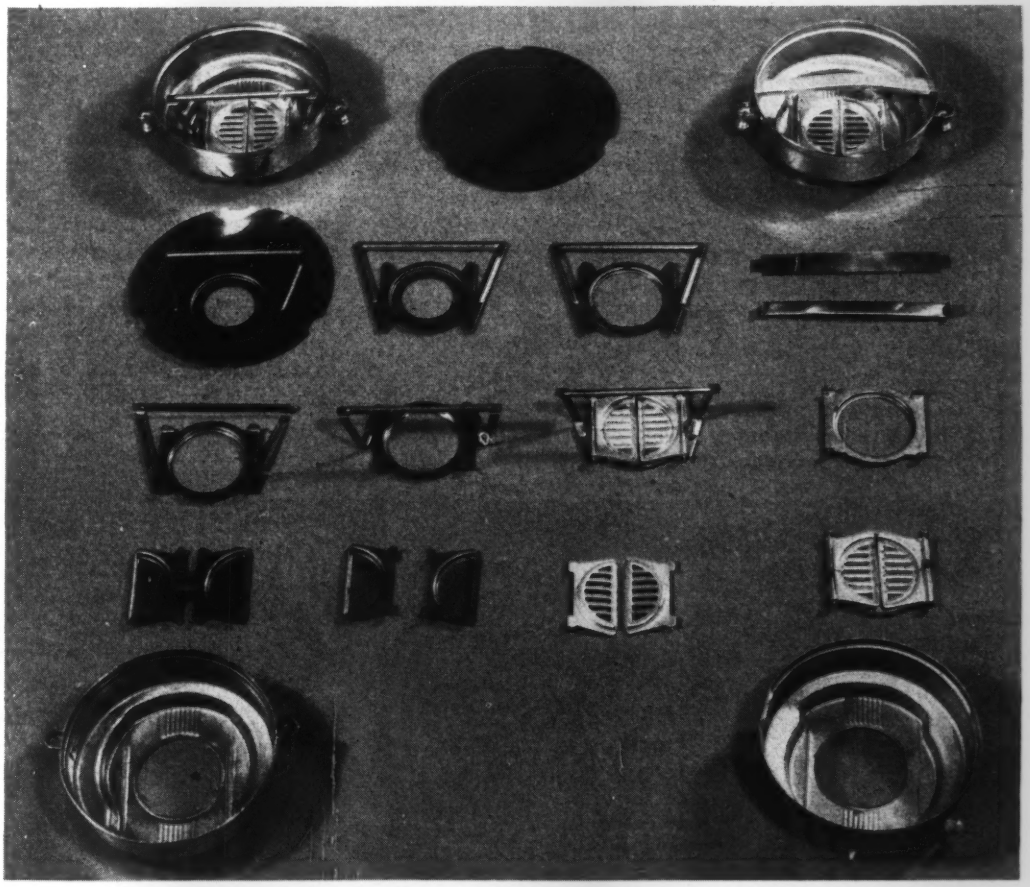


Fig. 3 — Original cleaner filter housing parts, right, and new design using integral parts and balanced production shown in the three groups from the left

tained sufficient material to make a new design of louver frame which combined the protection bar and frame in one piece. With only one added press operation on the louver frame, the new design eliminated two operations on the old bar and two operations on the filter housing and filter housing assembly itself.

At the bottom of *Fig.* 3 are shown several of the operations on the louver doors. Originally these were made singly, but they are now being blanked and drawn in a double-die, making right and left in the same operation. The operation of bending the ears and cutting apart is combined in one operation and right and left louver-piercing dies are combined together on one die shoe, giving a pair of rights and lefts with the same handling and in complete production balance.

Standardized Design Cuts Cost

In sheet metal box and cabinet design where a range of sizes is to be made, frequently it is possible to make corner radii, fold-over dimensions, size and spacing of holes, size of special cutouts, etc., standard for the entire line. This will permit a single set of radius bars, brake stops and multiple piercing dies to be kept set up with little or no changeover time, even if size of individual lots is small and on a made-to-order basis.

Hole layouts can frequently be simplified to reduce the number of sizes. There is little difference in cost of screws, nuts or rivets in sizes between $\frac{1}{8}$" and $\frac{1}{4}$" and frequently a design can, for instance, be made all No. 10 instead of No. 6, No. 8 and No. 10. Three sizes of screw holes mean setting up three drill spindles for tap size drill, three spindles for tapping and, in the corresponding piece, three spindles for clearance holes and sometimes three more for counterboring or countersinking, a total of nine or twelve instead of three or four. Even in small-quantity production this is a large factor in cost. It may represent several thousand dollars of extra equipment in drill spindles tied up during operations on small quantity or continuously invested on straight-line setup. Even if multiple-drill heads are used, most efficient speed will probably not be possible for all sizes and assembly and stock difficulties remain.

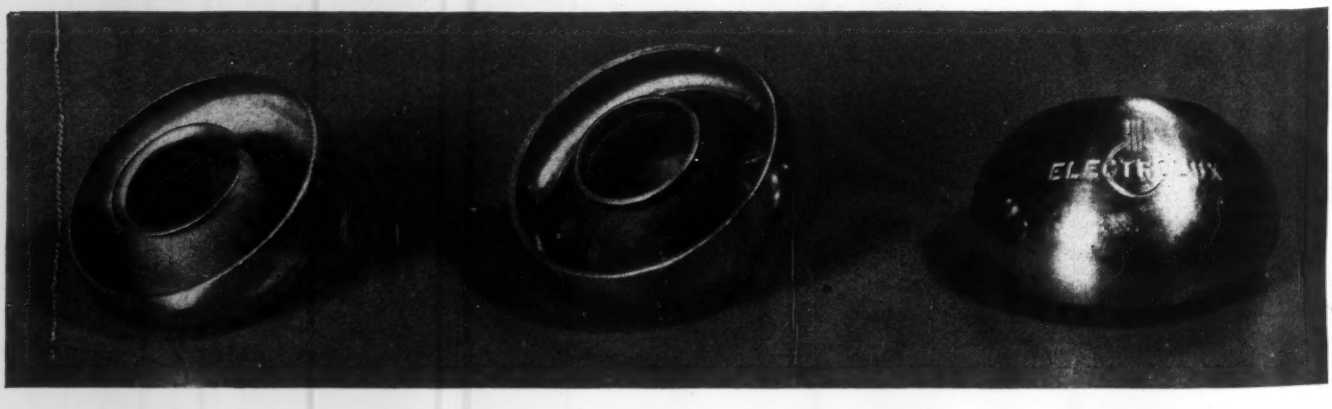
Choice of materials is important. For instance, castings, metal stampings and molded plastics each have certain advantages, both from product and manufacturing angles. Periodic review of designs and careful analysis of new designs should always be made before making a selection. We have found that the postwar answer has been different in many cases from the prewar answer.

Improvements in processing technique and in the physical properties of basic materials also often permit new applications. A good example is the round or dusting brush body shown in *Fig.* 4 with a top view of the finished part, bottom view of the metal stamping and the diecasting which superseded it. A series of fifteen difficult operations were required to make the original metal stamping. Die maintenance was high and specially selected deep drawing material was required to withstand the severe draws without splitting. One of the earlier objections to making this part as a diecasting was the fact that the design shape required more than half a sphere, and it was believed that a machining operation would be required because the part otherwise could not be ejected from the diecasting mold. Investigation showed that ductile alloys were available and the necessary shape could be obtained by one simple punch press swaging or curling operation on the finished casting.

Preplating Solves Problem

Another case of materials selection is that of a fan housing originally drawn from a square blank of sheet steel. Zinc plating in conventional still tanks after fabrication required that the plating operator tilt the parts on removal from each solution to drain any pockets. When attempt was made to apply automatic plating, it was found that the parts were not self-draining and rapidly contaminated the solutions when racked in the previous manner. If racking were done so that the parts would be self-draining, a gas pocket developed, with inferior plating on the upper inside portion. Solution to the problem was to preplate the blank and perform the fabricating operations after plating. Results showed that the zinc plating was sufficiently ductile to withstand the drawing operation, thickness remained adequate for protection, and that it had a lubricating effect which actually increased die life.

Fig. 4—Improved materials made possible production of brush body from diecasting, center, eliminating majority of operations required for original stamped part, left



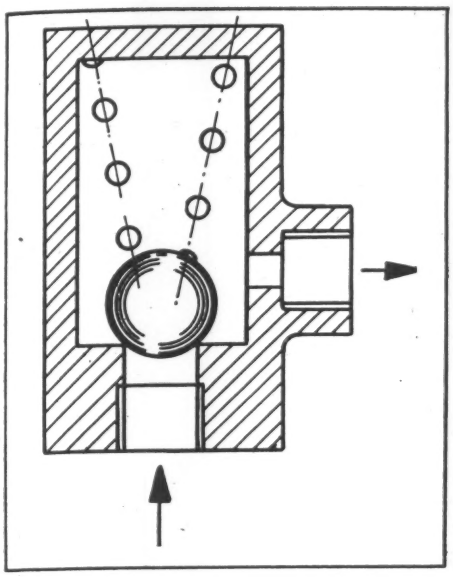


Fig. 1 — Left — Conventional type relief valve in which seat pressure is proportional to difference between fluid pressure and spring load

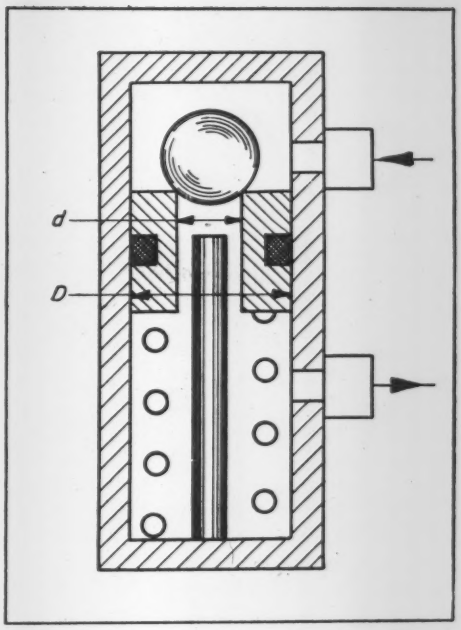


Fig. 2—Right—Inverted relief valve in which seat pressure is directly proportional to fluid pressure up to the pressure at which the abutment contacts the valve

By H. G. Conway
Technical Director
British Messier Ltd.
Gloucester, England

Inverted Relief Valves

. . . provide positive action with freedom from dribble. Supplementing the article on "Selecting Hydraulic Pressure Control Valves" in the April issue, this article discusses the characteristics of inverted valves and illustrates typical designs

HOW a fresh viewpoint can lead to improvement of a well established design, *Fig.* 1, is strikingly illustrated by the case of the inverted relief valve, *Fig.* 2. Conventional relief valves use a ball, poppet or disk, spring loaded onto its seat, usually by a compression spring but sometimes by a tension spring.

A ball type valve is shown diagrammatically in *Fig.* 1. An unguided valve is common on low-pressure valves but the valve is unstable laterally when open and may vibrate across the seat. For this reason it is better practice, particularly on high-pressure valves, to guide the ball and allow it to move axially only, and usually to rotate. From the point of view of lateral stability the tension spring design is to be preferred.

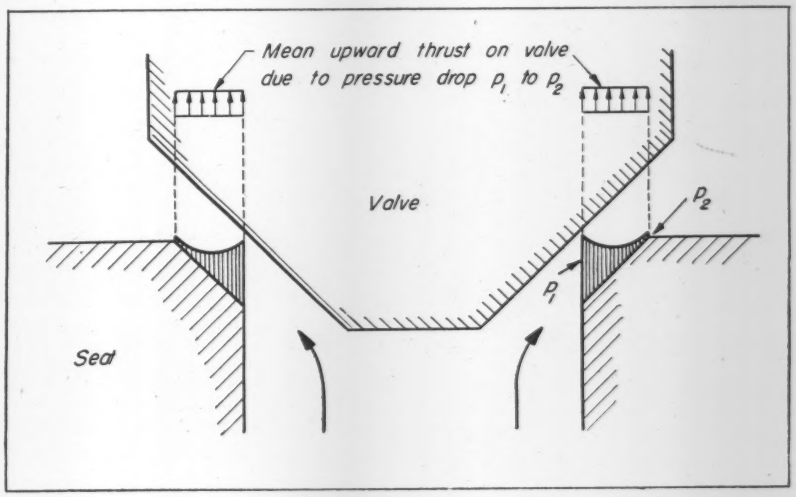


Fig. 3—Pressures acting on an open valve, showing the excess thrust over that existing when the valve is closed

although the spring mounting is less satisfactory.

DEGREE OF VALVE LIFT: In order to appreciate fully the functioning of a relief valve it should be realized that the valve dissipates the pressure energy of the fluid by converting it into kinetic energy and heat, the fluid being forced to accelerate to a high

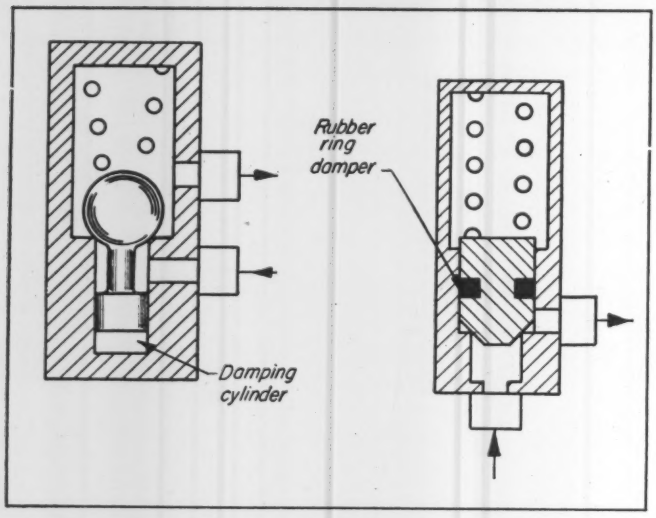


Fig. 4—Two methods of damping a conventional relief valve so as to minimize vibration and noise

speed. Speed of the fluid through the valve is high and thus the actual lift of the valve is small; how small will be shown by the following calculation.

If the pressure at which the valve is set is p (psi) and the velocity of the fluid through the valve is V (in. per sec) then the familiar Bernoulli's equation can be written:

$$p = \frac{\rho}{2g} V^2$$

where ρ is the density of the fluid (lb per cu in.).

Let the valve diameter be d (in.) and let h be the valve lift (in.). Then the quantity of fluid passing through the valve is

$$Q = c\pi dhV$$

in cu in. per sec, where c is a factor called the orifice contraction coefficient. Hence

$$p = \frac{\rho}{2g}\left(\frac{Q}{c\pi dh}\right)^2$$

which gives

$$h = \frac{Q}{c\pi d}\sqrt{\frac{\rho}{2gp}}$$

If flow Q is in gallons per minute; $\rho = 0.032$ lb per cu in. (a mean figure for light mineral oil); and c is assumed as 0.52 (approx); then the formula can conveniently be written

$$h = 0.015\frac{Q}{d}\sqrt{\frac{1}{p}}$$

From this equation a simple calculation will show that a ¼-in. diameter valve set at 2500 psi will lift about 0.0072-in. when the flow is 6 gpm; and a 1-in. diameter valve set at 400 psi will lift about the same amount when the flow is 10 gpm.

The small magnitude of these lifts is not generally appreciated; many valve designs provide for considerable excess and wasted lift; a nominal lift of 0.05-in. is ample on normal valves. Again, the valve throat diameter is often made excessively large, and since the spring must also be large, the whole unit is excessively bulky and costly.

VALVE REGULATION: It is well known in relief valve practice that considerable troubles are often experienced with valve oscillation, noise and poor regulation. The regulation of a relief valve is the relationship between the pressure at which the valve opens and that at which it closes again; in a valve with good regulation the difference is small.

Why there should be this difference is illustrated in *Fig.* 3. When the valve is just about to open, the spring load is just balanced by the hydraulic lifting

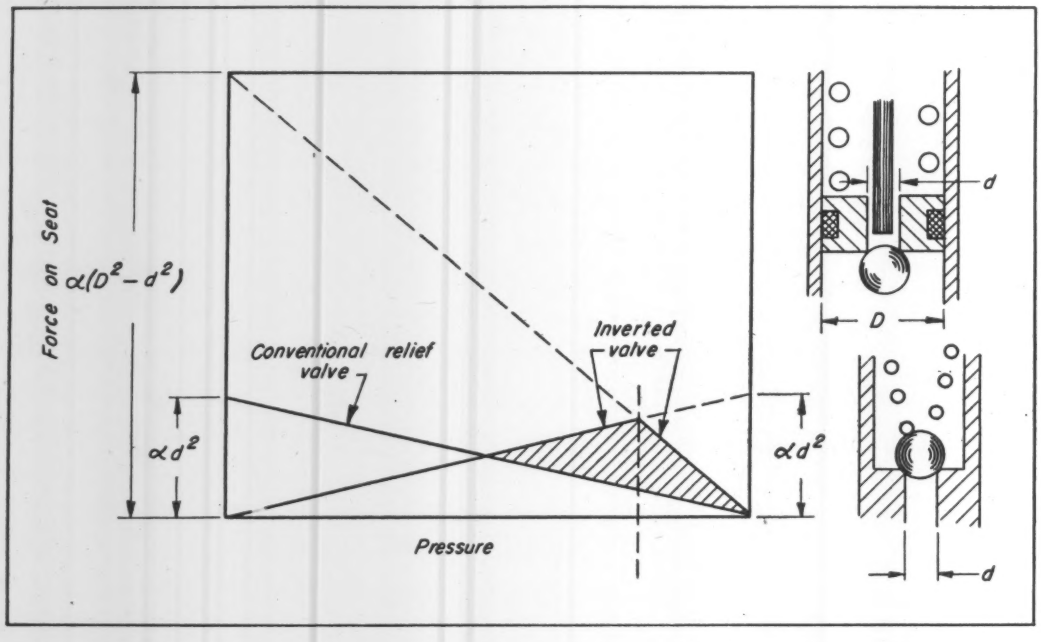


Fig. 5—Characteristics of both conventional and inverted relief valves. Shaded area shows advantage of the latter type over the former

pressure. When the valve is open the pressure drop is not instantaneous but is graduated along a pressure gradient across the width of the valve seat. As the seat width is finite and often appreciable, when the valve lifts the pressure acts on a larger area, tending to open the valve wider. This effect causes valve vibration and noise; it can be cured partially by making the seat very narrow, or by damping the valve as shown in *Fig.* 4.

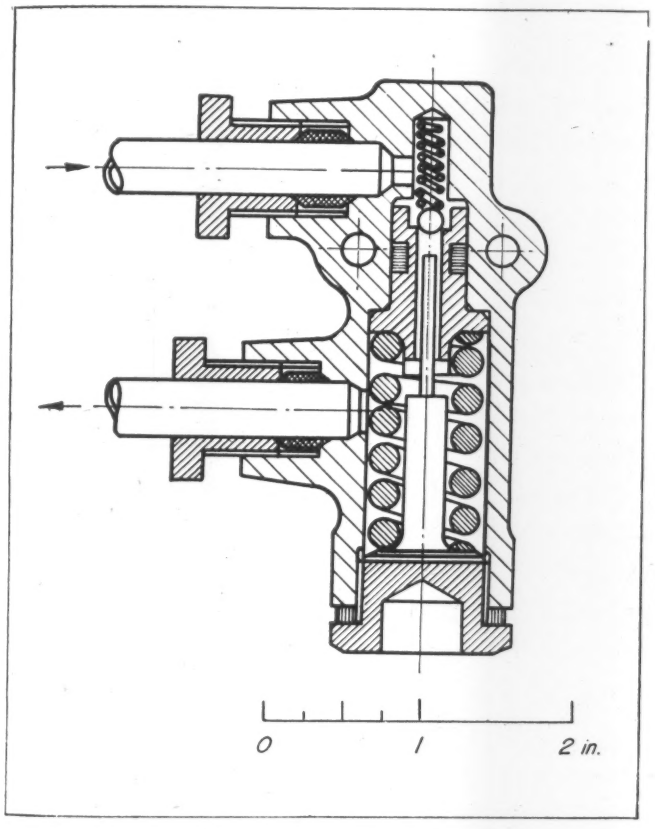
Enlargement of the effective valve diameter when the valve opens also means that the pressure will drop to a lower pressure than that of opening before the valve will shut. A narrow seat thus improves regulation.

INVERTED VALVE: The conventional type of valve so far discussed and illustrated suffers from the disadvantage that the force between the valve and seat is reduced as the pressure rises, being zero when the valve lifts. This means that the valve is sensitive as the pressure approaches the opening point, and will tend to seep or dribble prematurely.

An interesting and comparatively unusual relief valve of the so-called inverted type is shown in *Fig.* 2. This valve differs from the normal type in that the valve member is pressed onto its seat with increasing force as the pressure rises, until such time as an abutment (a small rod in the illustration) lifts the ball away from the seat and the valve is thus opened. The valve should be expected to have superior characteristics from the point of view of premature leakage, and this is in fact borne out in practice.

It is not known who the original inventor of the inverted relief valve was but undoubtedly its first application on aircraft was by the French Messier company in 1935. Since that date this type of valve has been more or less standard in that country and widely used in England by the British Messier company since 1938. In addition, a wartime technical committee of British airplane hydraulic manufacturers adopted this design for full-flow and thermal-relief valves with considerable success. The actual constructions adopted are illustrated later.

Fig. 6—Original French design of inverted relief valve, with a maximum pressure setting of 3000 psi

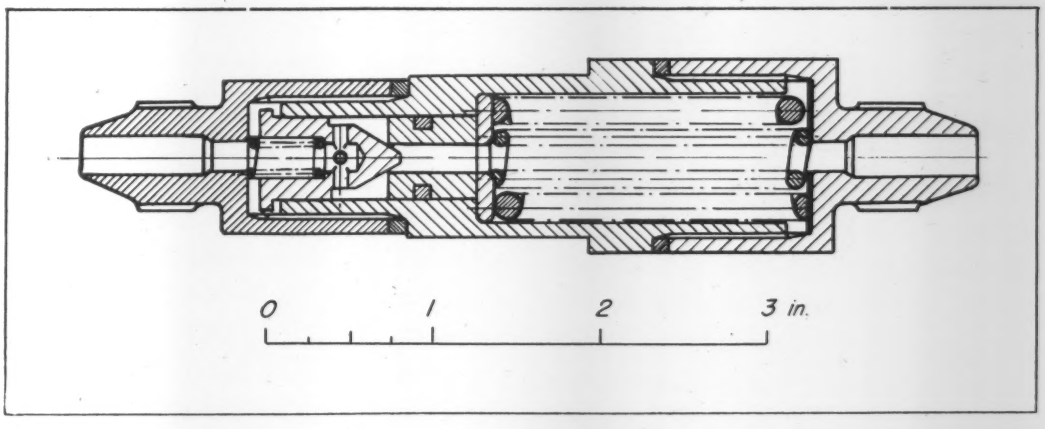


How the Inverted Valve Operates

What actually happens in an inverted valve is shown more accurately in *Fig.* 5. The conventional relief valve has a seat force characteristic curve which is a straight line down to the opening pressure. The advantage of initial spring tension in making the valve less likely to dribble by increasing the slope of the seat force curve is obvious, but the improvement is small with any practicable degree of initial tensioning. In the case of the inverted valve the valve seat moves as a piston as the pressure rises, compressing the spring, until the valve strikes the rod abutment. The pressure at which the abutment is contacted is proportional to the ratio of the annular area between the valve seat and the piston to the full piston area, $(D^2-d^2)/D^2$, and thus it is advantageous to keep this ratio as large as possible for maximum anti-dribble properties.

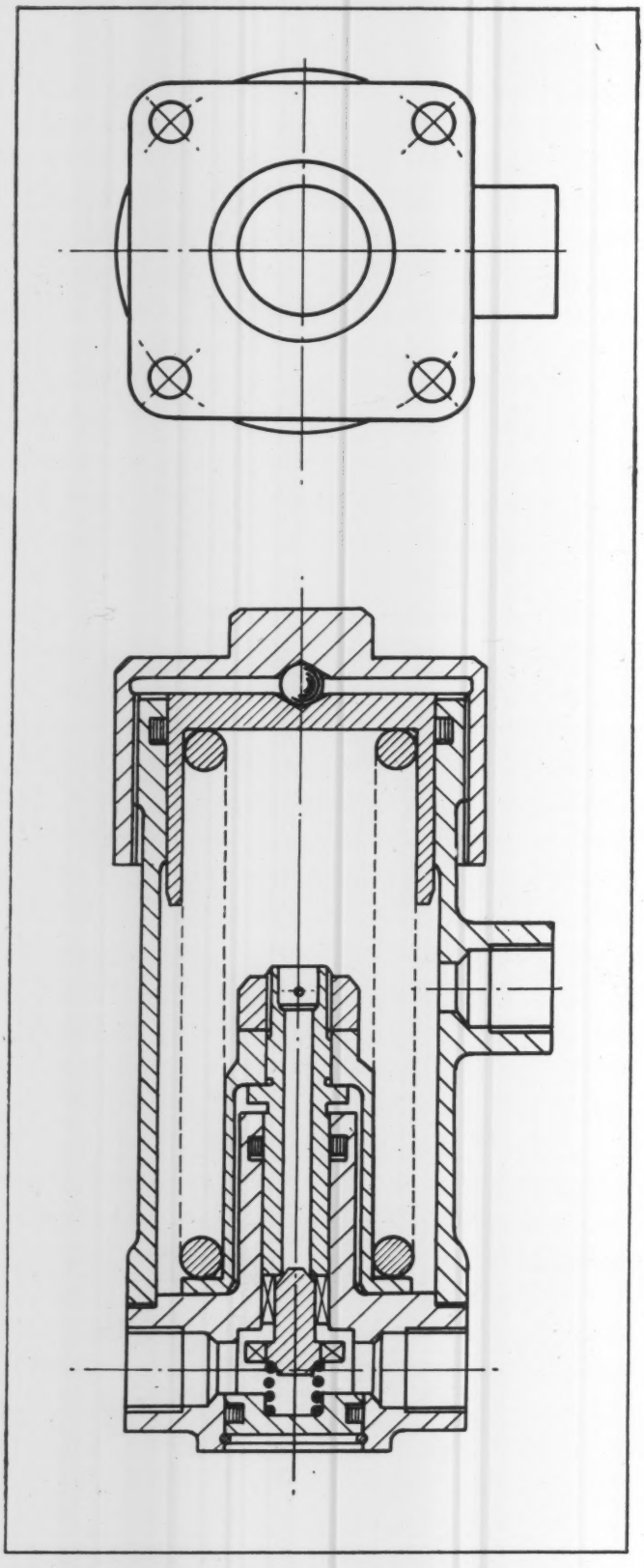
After contact with the abutment, the pressure acts

Fig. 7—Improved design of inverted relief valve employing poppet valve with shouldered head which engages the abutment



on the annular area between piston and valve seat and the pressure increases until the seat moves away from the valve. During this stage the valve acts as a normal relief valve except that the slope of the seat force curve is exceedingly steep and equivalent to a

Fig. 8—New design of inverted relief valve for operating pressures up to 4500 psi



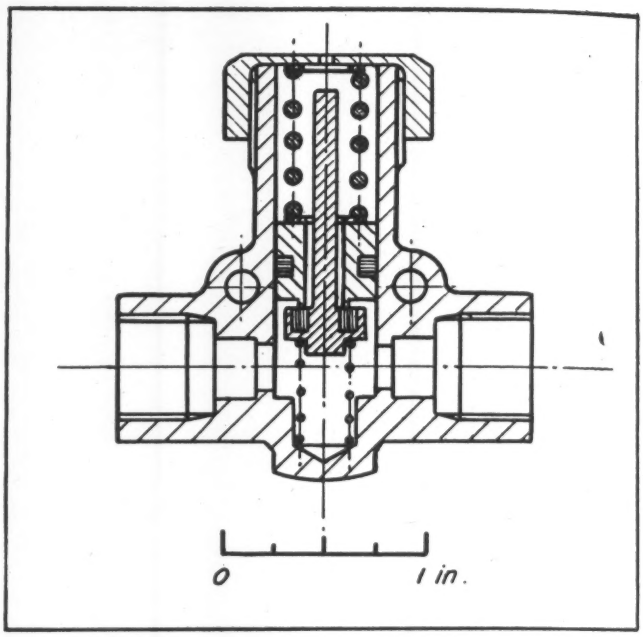


Fig. 9—Pneumatic relief valve designed on the inverted principle for 1500 psi maximum pressure

normal valve with a very great initial spring tension. The shaded area in the figure is a measure of the advantage of the inverted valve over the normal type of valve.

Another fundamental advantage of the inverted valve is that, since a piston seal is necessary, the motion of the valve is heavily damped by the seal friction, which is a highly desirable attribute. Excessive friction, however, will cause a lag in the closing of the valve as the pressure drops, and will tend to affect the regulation. It is true also that while a seal may be acceptable on an airplane valve, its relatively limited life may not be acceptable on some machine equipment which has to operate for long periods. In these cases a lapped fit between piston and cylinder may give sufficiently leak-proof performance.

Actual Designs Discussed

DESIGNS OF INVERTED VALVES: The original French Messier valve of 1935 is shown in *Fig.* 6. This had a maximum pressure setting of 3000 psi, a 10-mm piston and a 5.5-mm ball on a 4-mm seat. This gave an abutment pressure of $(10^2-4^2)/10^2 = 84$ per cent of full pressure, which is satisfactory for most purposes. The ball was lifted by a 3-mm steel rod whose length was adjusted by filing for fine pressure setting, shims under the spring being used for coarse setting. The disadvantage of this design was that at large flows the 1-mm gap around the central rod was insufficient and limited the capacity of the valve, although regulation and steadiness were excellent.

A revised British standardized wartime design therefore was produced, and is shown in *Fig.* 7. In this the valve was changed to a poppet with a shouldered head which acted on the appropriate abutment. In this design, again with a maximum pressure of 3000 psi, the abutment ratio is $(0.5^2-0.187^2)/0.5^2 =$

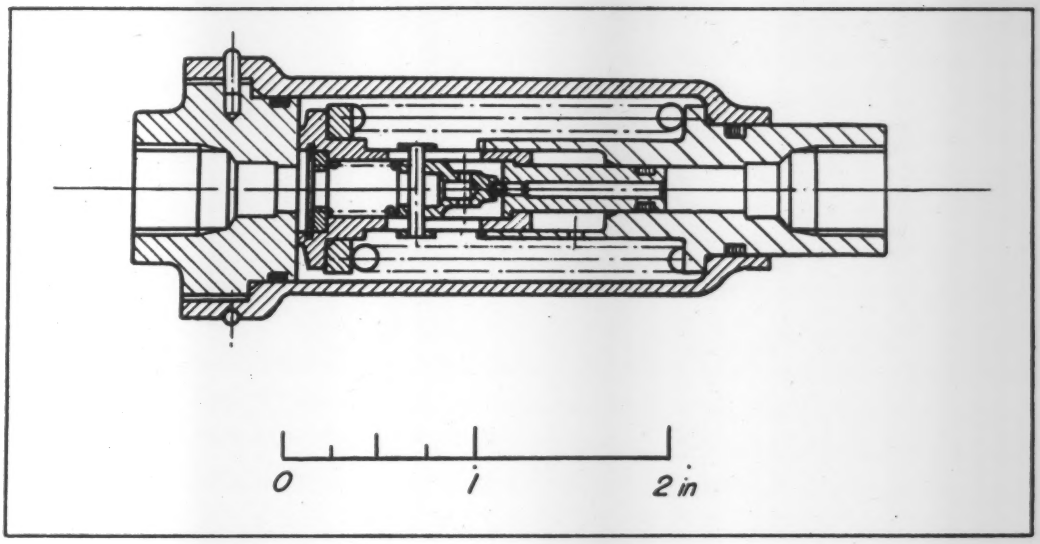


Fig. 10—Inverted thermal relief valve which also handles appreciable flow as a safety valve

89 per cent. Owing to the absence of a restriction in the valve throat the flow capacity of the valve is excellent. Regulation and steadiness are good.

A new British Messier design, having a maximum pressure of 4500 psi is shown in *Fig.* 8. The piston diameter is 0.4-in., the valve throat 0.15-in., and the abutment ratio 86 per cent. In *Fig.* 9 is illustrated a 1500-psi pneumatic relief valve utilizing the inverted principle.

THERMAL RELIEF VALVE: An important component in many hydraulic systems is a valve designed to relieve excess pressure due to thermal expansion of the fluid, thus avoiding damage to the pipes or components. A thermal relief valve is probably the most difficult type of valve to design unless the valve can be set appreciably above the maximum system operating pressure. Under the conditions of slow pressure rise which occur with thermal expansion the ordinary relief valve is effective enough but in a practical system the existence of pressure wave effects completely upsets its performance.

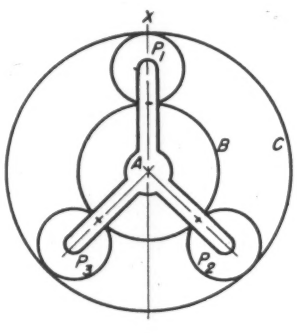
Each time the pressure changes rapidly, as when valves are opened or closed or a hydraulic cylinder abuts, pressure waves travel along the fluid columns in the pipes; these surges make an ordinary thermal relief valve dribble and leak unless, as already indicated, it is set with an ample pressure margin.

The great advantage of the inverted relief valve is that its piston acts as a dynamic energy damper, and merely by providing it with adequate displacement capacity, it will not dribble or leak even in a system subjected to severe hydraulic shocks. *Fig.* 10 illustrates a thermal relief valve with a rated pressure of 4500 psi; it will actually deal with an appreciable flow as a normal safety valve. Valves operating on this principle have been widely used in England for several years and have proved much more satisfactory than the earlier plain types.

Planetary Gear Design

COMMENTING on the engineering data sheet "Planetary Gear Calculations", MACHINE DESIGN, March, 1948, Page 165, Prof. W. A. Wolfe, University of British Columbia, writes:

"When more than one planet gear is used, the problem arises of determining the number of teeth in the two sun gears so that the planet gears can be fitted on equally spaced axes on the planet carrier. The relation may be developed as follows, referring to the accompanying sketch:



"Let C = number of teeth on ring gear, B = number of teeth on spur gear (assumed fixed), and n = number of planet pinions. When the arm A has rotated $1/n$ revolutions, planet pinion P_2 will be in the position X that P_1 was in initially. Since P_2 meshes with fixed gear B it must also be in the identical position with respect to the orientation of the teeth. This requires that the number of teeth on gear C passing the point X must be a whole number; that is, $N_{cf} \times C$ must be a whole number, where N_{cf} is the revolutions of gear C with respect to the frame. For the design shown in the sketch, with B fixed, Equation 6 of the data sheet referred to becomes $N_{cf} = N_{af} \times (B + C)/C$. Therefore, since $N_{cf} \times C$ must be a whole number and $N_{af} = 1/n$, the requirement is that $(B+C)/n$ must be a whole number. In an actual example $B=23$ and $C=79$; it is required to check whether 3 planet pinions can be employed with equal spacing. Substituting, $(23+79)/3=34$, so the condition is satisfied."

Low-Torque Potentiometers

. . . simplify many control problems

By H. D. Wright
Engineer
G. M. Giannini & Co., Inc.
Pasadena, Calif.

OFTEN the designer is confronted with the need for measuring and transmitting data from relatively weak signals. In such instances low-torque potentiometers have been applied to advantage. Many variables including rate of flow of gases or liquids, liquid levels, temperatures, amperage, *Fig.* 1, and accelerations may be measured and the data transmitted to a receiver for controlling a process or machine function. Potentiometers have also

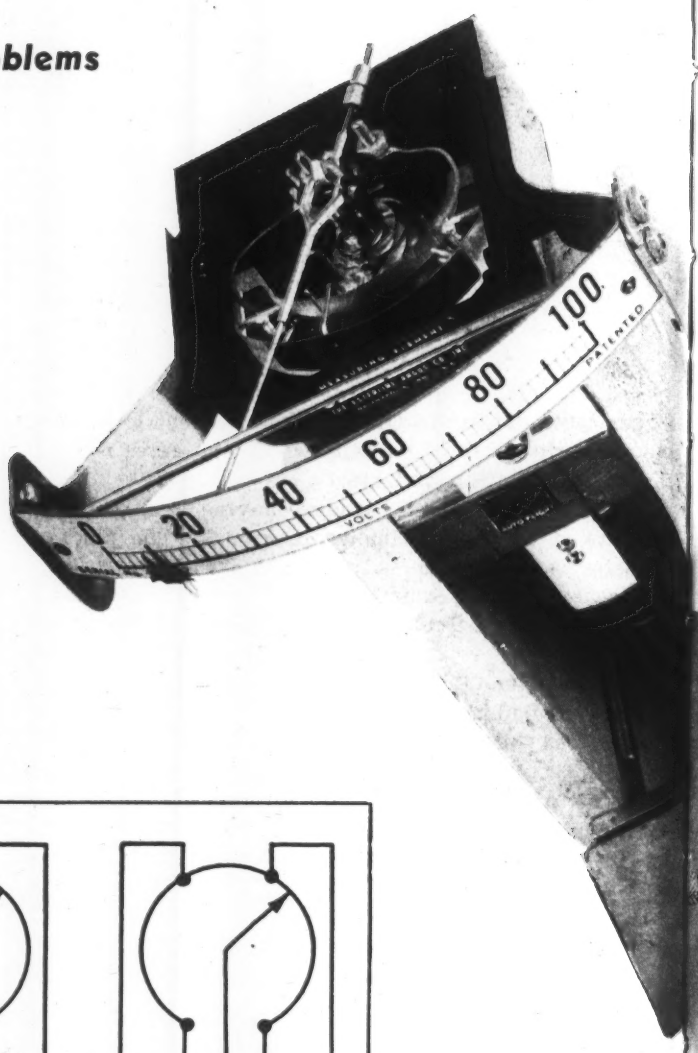


Fig. 1 — Above — Low-torque potentiometer, used in conjunction with galvanometer, transmits data on current variation. Potentiometer is located just below instrument needle

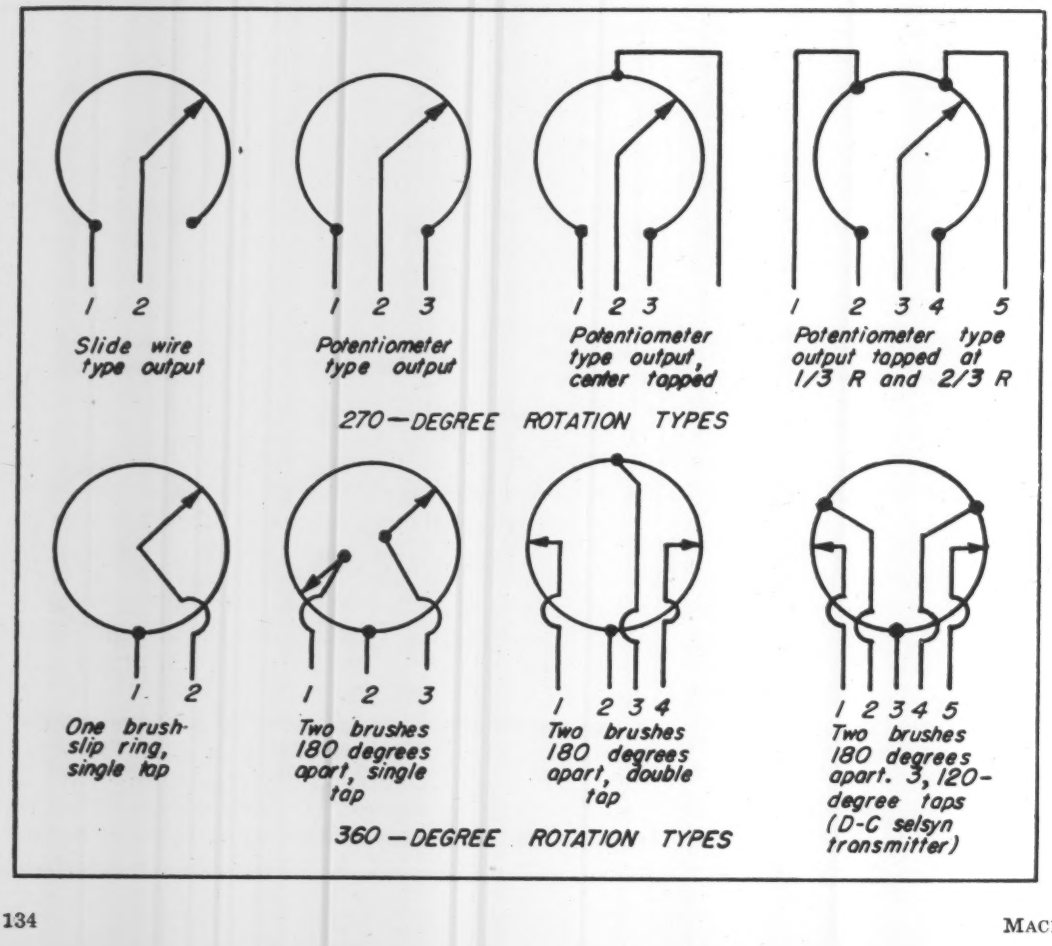

1 2
Slide wire type output
1 2 3
Potentiometer type output
1 2 3
Potentiometer type output, center tapped
1 2 3 4 5
Potentiometer type output tapped at 1/3 R and 2/3 R
270—DEGREE ROTATION TYPES
1 2
One brush slip ring, single tap
1 2 3
Two brushes 180 degrees apart, single tap
1 2 3 4
Two brushes 180 degrees apart, double tap
1 2 3 4 5
Two brushes 180 degrees apart. 3, 120-degree taps (D-C selsyn transmitter)
360—DEGREE ROTATION TYPES

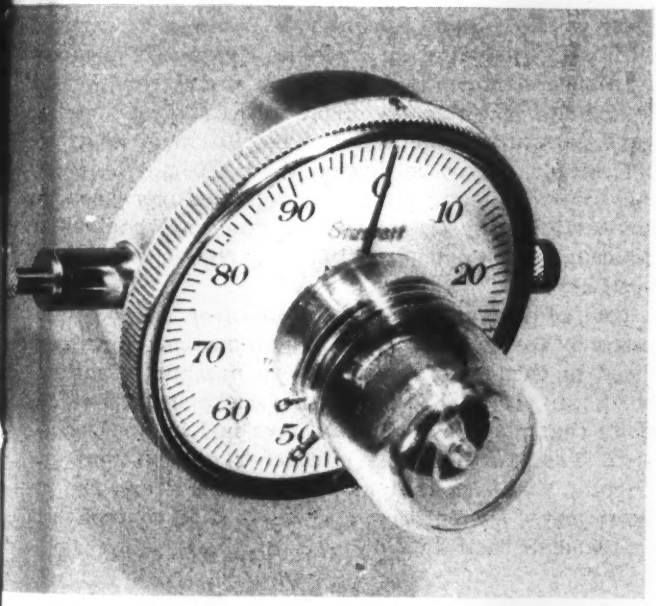
Fig. 2 — Left — Typical circuits of low-torque potentiometers

found important applications in conjunction with profiling, in measuring shaft positions of low-torque machines and in the follow-up or sensing sections of servomechanisms.

Compared to other types of variable-voltage or frequency devices for use in recording systems, potentiometers have distinct advantages. For example, a strain gage type of sensing element requires the use of electronic amplifiers and consequently the zero drift of the strain gage becomes a serious problem. Inductive type instruments have the disadvantage that the frequency varies seriously when the temperature in the air gap has been changed to a relatively slight degree. Little real improvement has been accomplished in the design of inductive elements.

Potentiometers with low-torque characteristics were first developed in Germany during World War II by a man named Patin who later formed a company for their manufacture. A major portion of German gyro equipment, compasses and other flight instruments incorporated the use of these small potentiometers. The capture of some of these instruments brought the design to this country. At that time, little use was found for the potentiometer, but as stress upon basic simplicity of designing instruments and mechanisms increased, the unit became an important device in the eyes of the designer. A few of the basic characteristics of the potentiometer responsible for its importance are: Resistances, 100 to 25,000 ohms; maximum brush current, 0.1-ampere; linearity, 0.2 per cent; torque required, 0.003-ounce-inch; and theoretical angular resolution, ¼ degree at 5,000 ohms. The moving parts are statically balanced and therefore the instruments can be adapted to gages or utilized as components where severe vibration conditions exist, without detracting from the accuracy of measurement. The potentiometers are wound in many different wiring configurations, *Fig.* 2, so that cycling, zero reference in midscale and sawtooth and selsyn type voltage outputs can be obtained for recording purposes. Since the maximum benefit can be obtained from an instrument only by knowing how it may best be used, the remainder of this article will be devoted to describing typical uses to which the potentiometer has successfully been put in actual practice.

Fig. 3—Below—Mounted on the face of a dial-micrometer gage, potentiometer can be used for control or remote reading of thickness, etc.

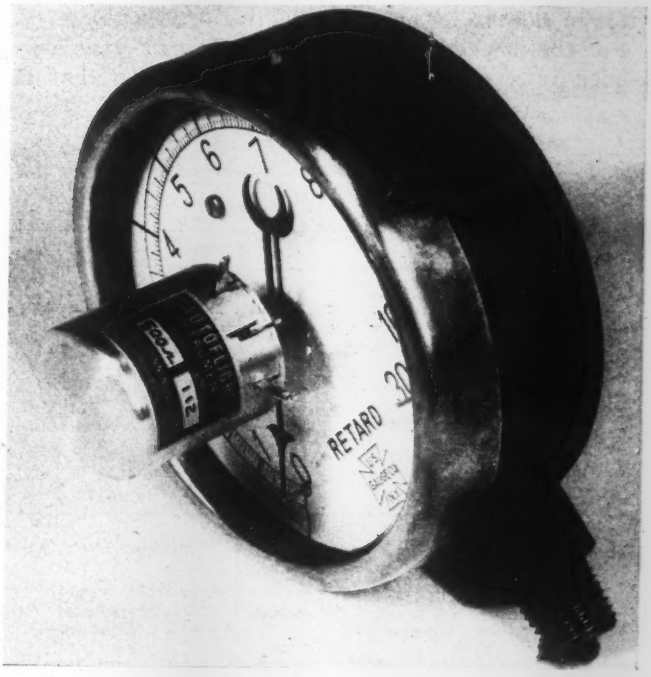


Can Be Mounted on Gage

The combination of a low-torque potentiometer and a standard dial micrometer gage, *Fig.* 3, has had wide application, one of the most important of these being for the measurement and recording of material profiles. The gages can be modified by replacing the standard glass face with a plastic cover, suitably drilled and tapped to accept the mounting boss of the instrument. Such modified instruments produce full electrical signal for 0.005-inch movements. The hysteresis effects of the modification can be kept to a minimum and in some special cases the spring of the dial micrometer gage can be replaced with a spring having large spring rate in order to take up the backlash and rotate the potentiometer down the scale. The same modification has been used for making recordings of engine-mount displacement and beam distortion.

Liquid-level measurement in process containers where float type systems are impractical can be made and recorded easily by pressure type elements. A potentiometer mounted on a standard instrument can give good resolution of liquid level for the major portion of the tank and greatly increased resolution

Fig. 4—Below—Potentiometer mounted on bourdon-tube gage can be used to control such variables as pressures, liquid levels or fluid flow



at the lower tank levels. This provides a simplified method of controlling the liquid level in the low level where most control and recording is required.

Mounted on the face of an altimeter, differential pressure, or bourdon-tube instrument, *Fig.* 4, a potentiometer will furnish an electrical voltage for the pressure that is indicated on the dial, therefore the pressure variable can be recorded with a minimum of design change. However, where this may not be convenient, the differential pressures that exist between the constricted and large opening of a venturi tube provide an easy method of measuring high rates of flow to an excellent degree of accuracy.

For the measurement of low flow rates a vane suspended in a stream provides an installation that is compact and which has an excellent degree of resolution, approximating 0.3-inch of water differential pressure from one side of the vane to the other. This has provided a system of satisfactorily sensing a rate of change of altitude equal, approximately, to ten feet per minute or recording the position of a body with respect to an air or fluid stream within 0.125-degree.

Temperature recordings and indications have been made by the adaptation of a potentiometer element to a bimetallic helically wound spring which rotates when subjected to varying temperature. These bimetal elements are suitable for ranges up to approximately 300 C, a potentiometer coupled to the rotating element furnishing an electrical signal output.

The control and position measurement of a gyro-stabilized platform, such as used for camera mounts, can be accomplished by using low-torque potentiometers. This type of installation provides a negligible amount of drag on the gyro, platform, and erecting or precessing assembly. The large outputs allow direct control of the precessing device without using electronic amplifiers.

TABLE I—Typical Applications of Low-Torque Potentiometers

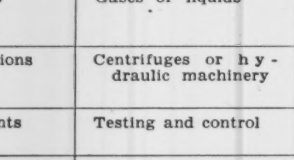
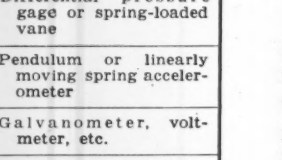
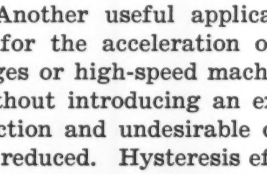
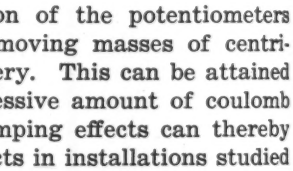
Variable	System Controlled	Associated Devices
Water levels	Tanks	Sensitive pressure gage. Water depth is obtained as a function of pressure
Liquid levels	Process containers	Arm and float
Pressures	Gases or liquids	Pressure-sensitive instrument, potentiometer coupled to the instrument hand
Temperatures	Gases or liquids	Bimetal temperature probe or pressure type thermometer
Shaft positions	Low-torque machinery	Cam or gear device driving the potentiometer
Fuel flow	Gases or liquids	Differential pressure gage or spring-loaded vane
Accelerations	Centrifuges or hydraulic machinery	Pendulum or linearly moving spring accelerometer
Instruments	Testing and control	Galvanometer, voltmeter, etc.
Profiling operations	Control of paper thickness, etc.	Dial-micrometer gage
Expansion and contraction	Metals, plastics	Dial-micrometer gage
Applied forces	Testing machines, jet thrust, etc.	Dial-micrometer gage measuring extension of proving ring

Used for Acceleration Control

Another useful application of the potentiometers is for the acceleration of moving masses of centrifuges or high-speed machinery. This can be attained without introducing an excessive amount of coulomb friction and undesirable damping effects can thereby be reduced. Hysteresis effects in installations studied have been negligible and the resolution of some accelerations has been better than 0.02*g*. This low measurement suggests many applications such as measuring drag of a body in fluid and controlling rotating equipment to a high degree of rotationary accuracy.

One of the most important uses of the potentiometer is for controlling remote transmission systems. Used in this manner there are a number of suitable electrical circuits. Four of the more important circuits that may be used are shown in *Fig.* 5. In addition, TABLE I indicates a number of the more important variables that may be measured and the potentiometer system that may be used to control them or transmit their data.

Fig. 5—Typical circuits in which potentiometers can be used as transmitters

Circuit Schematic				
	D-C Selsyn	Voltage-Ratio System	Two-Wire System	Wheatstone-Bridge System
Receiver	D-C Selsyn	Voltage-Ratio Meter	Indicating or Recording Ammeter	Ammeter, Galvanometer, Oscillograph, etc.
Advantages	Self-Compensated for Voltage Changes	Self-Compensated for Voltage Changes	Constant Voltage Source	Adjustable Circuit Constants

Program Controls

. . . a guide to their selection

By Albert M. Patterson
Engineer
*Seely Instrument Co. Inc.**
Niagara Falls, N. Y.

Fig. 1—Above—Six-station impulse-sequence type of time-cycle controller having push-button selectors for timing

A DEVICE by which a predetermined series of related events can be made to occur is a program control. When man first learned to plan ahead, he at the same time became the first program control system. Since then, his ingenuity has beeen at work transferring the burden of executing the programs planned in his constructive life to mechanical devices. He has done this for a number of reasons: To increase his productivity, to decrease his exertion, to make more uniform the product of his exertion, and to conduct a hazardous operation with safety. However, the greatest constructive value of program control is in production and quality control.

To many, program control conveys the idea of time-cycle control. Primarily that will be the concern of this article although its broader significance of dimension and sequence control will be indicated.

In planning a program control and selecting the devices to implement it, certain values must be weighed as to their relative importance. As in all engineering, the result attained must be a product of compromises, not the least of which is cost. The important factors concerned will therefore be discussed in some detail.

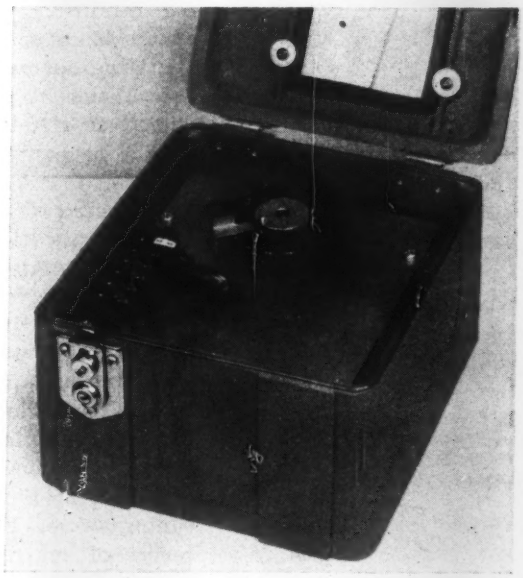


Fig. 2—Left—Mechanical interval timer, having fixed cam-speed, uses a graduated dial for adjustment

PRECISION: The selection of time control or limit control for each step of a program is determined by conditions of time, temperature, etc., requiring exactness. If limit control is needed, the measuring device and means of signal transmitting are selected to suit the systems to be used. For example, limit

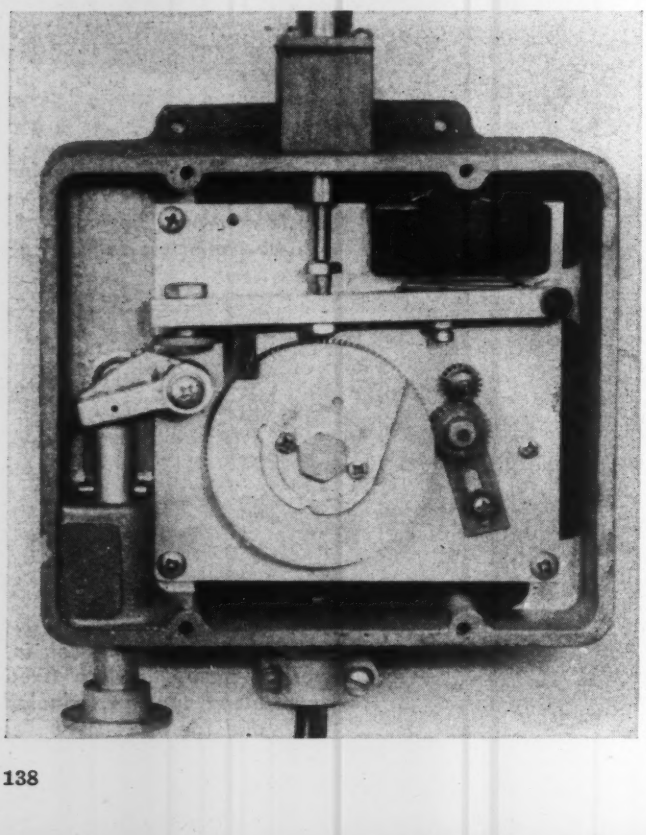
* Subsidiary of Aeronautical Mfg. Co.

valves or limit switches with stops or trippers would be used to control position and sensitive relays would be used to control voltage or current. If time control is either definitely indicated or is a satisfactory alternative, the degree of accuracy required will govern the type of timer chosen. Hot wire and bimetal time delays are less exact than air dashpot types. These are, in turn, less dependable than synchronous motor-driven interval timers or time-cycle controllers.

Exactness of the control attainable is also related to the range selected. For example, a thermostatic switch capable of being set between 0-500 F is more difficult to adjust to plus or minus one-half degree than one intended for a 100-250 F range. This is well illustrated by the operation of a timer consisting of a circular cam operating at constant speed. If a precision of plus or minus one per cent of the measured angular interval is sought using this cam, it may be readily attained when using nearly its full circumference. However, it is less easily attained as a decreasing amount of the cam circumference is used to measure the desired interval. At one-tenth of full available range, similar angular errors produce ten times the percentage error based on the original full interval. This is a weakness of quick-reset timers as compared to timers providing cam-speed adjustment. *Figs.* 1 and 2 are examples of the fixed cam-speed type and *Fig.* 3 is an example of an adjustable cam-speed unit.

A single-control electronic timer is subject to the same drawback unless, as is sometimes done, the adjusting scale is expanded in the direction of the lower end of the range. Further spread of time adjustment is imparted to some electronic instruments by varying the time constant through capacitor switching, much like changing gear ratios.

Fig. 3—Below—Program controller with manual start is a single-station type having changeable segment cam



STABILITY: While it is an important part of precition, stability is also desirable for itself so that established settings may be reproduced with consistent results. The required stability, like the required precision, guides the choice of equipment and the selection of its control. Basically, a timing device which is affected by variations in ambient condition should not be relied upon for close consistency. For instance, a metering type of tarry control on a grinder, while adequate for its purpose, is altered by the temperature and pressure changes of the oil admitted. Therefore it would not be used for timing a plastic molding cure. For comparable reasons a synchronous-motor driven timer fed by an electronic frequency changer is yet to be successful without elaborate and costly compensating provisions. Likewise, a process requiring attainment of a certain bath temperature before automatically admitting an ingredient would not be controlled by a timer because of variations in starting temperature, room temperature, incoming steam temperature, or barometric pressure. Instead, a limit control with a temperature-operated switch would be the logical choice. However, if because of some unusual corrosive condition a switch could not be obtained which could withstand the operating conditions, time control with very careful ambient condition control could be the solution to an otherwise difficult problem.

Wear May Cause Difficulties

Timing instruments which are subject to deviations because of wear should be regarded with suspicion. Frictional speed changers are unpredictable, and clutches for any but the lightest of torques have been a source of dissatisfaction. Although spring motors with escapement regulation have been developed to a high degree, their size and the amount of winding involved is against them for any appreciable power output.

Maximum stability is attained under wide operating conditions and with minimum maintenance by synchronous motors when a regulated-frequency alternating current is used in conjunction with positive drives such as gears. They are applicable to a broad choice of time-ranges and will be as stable as the regulating equipment in the power-generating system. This is, of course, provided they are not loaded beyond their rated torque. Overloading may be a result of misapplication, inadequate maintenance and, in some installations, improper adjustment of some part of the driven mechanism.

Electronic time references have been developed to the point where they are being relied upon for short-interval measurements. Units having stability to plus or minus two per cent are available for four to eight-minute interval applications. High-grade timers frequently include circuits for voltage regulation and a superimposed peaked voltage on the timing wave. For very short intervals measured in terms of multiples of the basic power-supply fre-

quency, such as have been used for spot and shot welding, electronic timers are especially well adapted.

RANGE: Unusual flexibility or uncertainty of future needs may demand timing equipment of very wide range. The disadvantage of using a fixed-rate cam for this purpose has already been discussed relative to precision. Extra-wide range is also possible by elaborate gear compounding or unusual large gear ratio provisions—with relative bulk and expense. If standard equipment built to satisfy the usual run of requirements (either with wide range and less consistent precision or with best precision but less range) does not suit the problem, resort may be made to special modifications of one or the other. Or it may be more economical to have several instruments with time ratings suitable to span the range, and interchange them as required.

Standard timers of the type represented by *Fig.* 2 offer a theoretical range of better than 100:1 which is available in a pinch, but are better regarded as 10:1 in practice. Their value lies in convenience of setting. *Figs.* 3 and 5 represent instruments with actual ranges of 4:1 available by changing a motor-shaft gear. *Fig.* 6 is an instrument with a range of 16:1 available by changing motor-shaft and worm-shaft gears. It is so built that little additional modification other than a gear change imparts an easily realizeable range of 960:1. *Fig.* 4 is a convenient timer which provides speed changes by shifter levers. It has a 10:1 spread with any given motor speed and internal compound.

Cycles May be Eight Days Long

These instruments are normally built for cycles of a few seconds to 750 minutes. In addition, timers are available for cycles of a week or longer and are generally synchronous-motor driven. However, one particularly interesting exception has been noted in the form of a spring-driven unit for petroleum well cycling on a daily schedule. This timer need be wound only every eight days. Electronic units for intervals over 20 minutes are rare. Four-minute interval units are more popular. Longer cycles are of course possible by cascading and building up a program in series to achieve whatever time is desired.

RESET: It is often desirable that reset—automatic return to the starting position—be achieved. This may occur immediately following a cycle or after a period of time known as runout. The character of a process determines whether provision must be made for runout. It will be found that the factors to be controlled, voltage for example, are of such a nature that: (1) Time is not consumed in restoring them to the starting value; (2) they are restored to the starting value in the normal course of the cycle; (3) they are returned to the starting value by some accelerating means or; (4) runout is accepted. The first condition takes care of itself, the second may develop naturally or may need to be planned for, the third usually needs special provisions to bring it about. The fourth is something to be avoided in most production situations for reasons of economy, although situations exist when such idle time is tolerable.

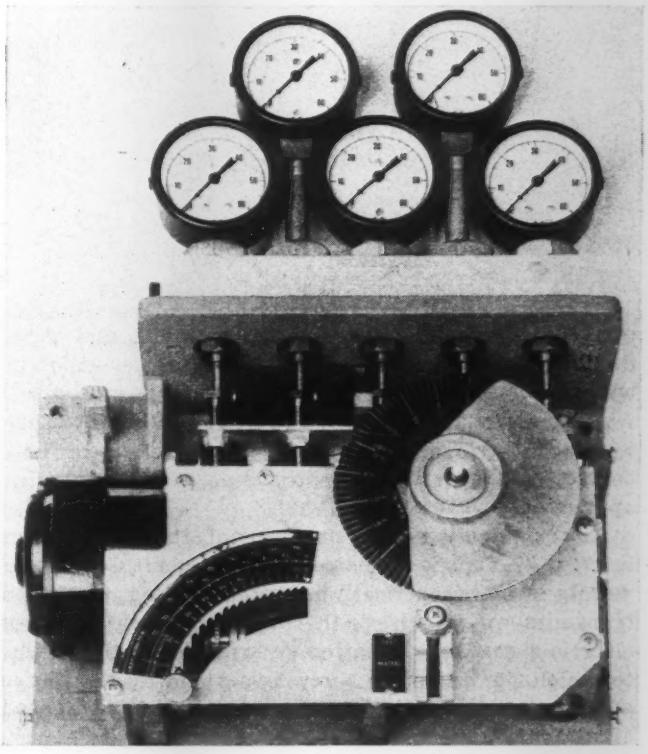
In timing instruments the first instance may be represented by the rapid recharging of the condenser in an electronic timer from the starting impulse which is in effect a resetting impulse. It is also represented by the mechanical interval timer shown in *Fig.* 2. This instrument stops after timing out an interval and is reversed by a relay which is then reset by the following starting impulse. Forward or backward the interval times out the same length period.

The second example may be seen in a controller having a speed changer such that the cam is adjacent to the starting position when the cam rider drops off the last lobe and terminates the operation.

Good examples of the second instance are the inexpensive manually reset timers offered by many firms for uses ranging from domestic to industrial, in which the cycle is started by manually adjusting the pointer to the desired value and releasing. Expiration of the timed interval terminates the instrument's cycle.

The third case involves reset timers. These may be actuated by some form of clutch to release the timing cam, which is then impelled by a spring to return. They may also be operated by a higher-speed motor drive which carries the cam forward to its starting position after release by an overrunning clutch. Interval timers offered by many manufacturers are spring returned since not more than two trippers are usually involved. Program timers and time-cycle controllers with more than a single pair of trippers or with a lobed cam

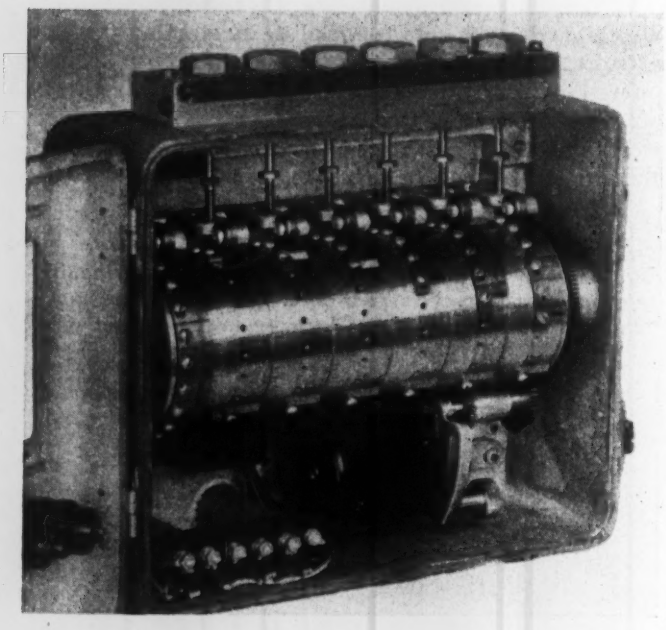
Fig. 4—Below—Five-station interchangeable or slideable-segment cam time-cycle controller. Instrument has quick-change gears and solenoid for momentary-contact start



may be spring returned if a means is provided for disengaging the sensing elements on the back stroke, otherwise a motor advance is usual. In *Fig.* 1, showing an impulse-sequence type of time-cycle controller, the wheel is a tripper program timer which is released by a mechanism other than a friction clutch and is spring reset. The sequence camshaft behind the straight row of keys across the top is reset in from one to four seconds, according to the program, by the same motor which indexes it. The fourth group represents no particular problem and its discussion would be of little value.

FLEXIBILITY: The ease with which changes in measured quantity or sequence may be made varies with the design, and the need is dictated by the purpose of the process. Changes in measured value are provided readily enough in many forms of limit control. Flexibility of sequence often requires more thought in limit control, but is a strong point of recommendation for present day time-cycle control devices if a choice between the two exists.

However, when all external conditons are sufficiently closely controlled or when the device being controlled is unaffected by the external conditions, a time-cycle control is one of the simplest and most flexible methods of cycle regulation. Cases exist in which time-cycle is the only possible form of control. At times it is an alternative to limit control, at other times it is complementary to a manual or a limit control and at still other times it is obviously inapplicable.



An extremely simple mechanical timer is shown in *Fig.* 7. It has but one cycle length. Consisting merely of an eccentrically mounted bearing, the timer transmits an impulse either by a pneumatic or an electric signal of a duration determined by the height to which the adjusting screw is set and by the motor speed selected. Cycle frequency is equal to the speed of the motor-driven eccentric. It may handle only one external control device, such as a cylinder, or one alternating with another, starting and stopping in response to an externally controlled circuit. Its original purpose was for "bumping" in a molding operation where gases were given off by the material in process. With calibration it could do "percentage timing." Either as shown or with a cam cut to special contours, it is a simple timer.

The interval timer, adjusted by a graduated dial like that shown in *Fig.* 2, covers wide ranges of time by stepless increments. It handles a device or devices concurrently or alternately with its periods of operation. It may be arranged to recycle itself giving off equally spaced pulses. For special cycles it may be combined in various ways either with others of its kind or with other timing and limit devices. By nature it is limited to handling an electrical signal.

Program timers are less convenient but in a sense are more flexible than interval timers for single circuits. A program timer may be used as an interval timer but more than that it can time out multiple intervals of nonuniform length in a cycle. It lacks the convenience of dial-and-pointer setting and may depend upon one of a variety of cam arrangements. The timing section of the instrument shown in *Fig.* 1 is, in effect, a program timer using what amounts to permanent key trippers and is an example of the next most convenient adjustment after the dial-and-pointer. Following this might be the slideable cam segment, next would be attachable key or pin trippers, followed by attached cam segments, and finally precut cams and punched tapes or disks. Much depends on circumstances. For example, when a certain few cycles are used repeatedly with frequent changes between, the cut cams and tapes may head the list. Choice would be governed by relative frequency of

Fig. 5—Left—Drum-type time-cycle controller has attached cam segments and changeable gear drive. Unit is a simple six-station type

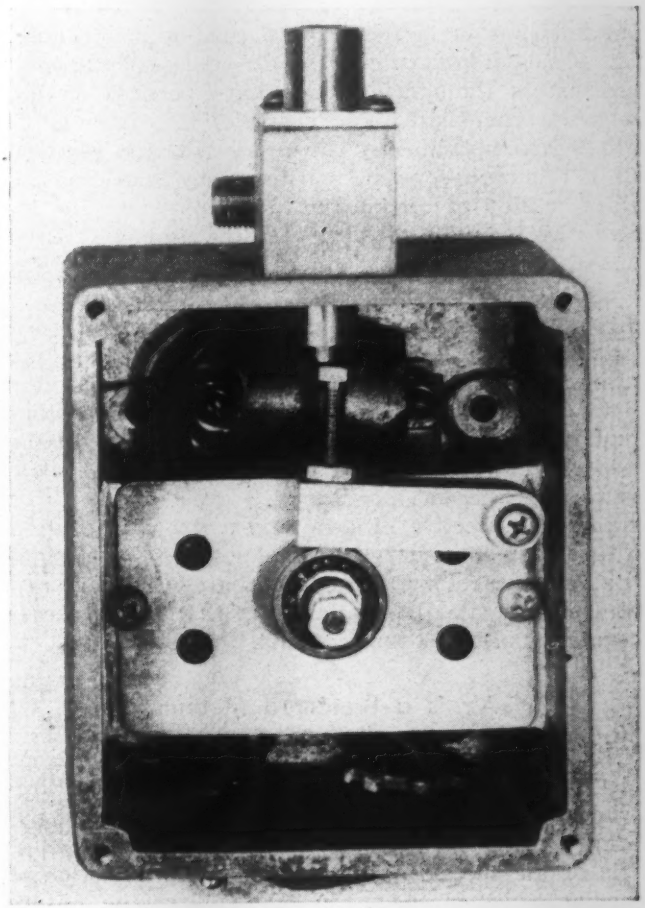
Fig. 6 — Right — Three-station drum-type time-cycle controller has solenoid for momentary-contact start. It is a changeable-gear, slideable-segment cam unit

change, frequency of repetition and cost of cams and of timers.

Program timers may be arranged to recycle continuously or to stop after each cycle. They may be connected to provide a schedule such as shown by *Fig.* 8 by paralleling components (valves, etc.) or connected to provide some similar schedule controlling more or fewer components. Sequence flexibility, however, is limited. Interval timers, while offering the flexibility of setting interval by dial and pointer, have the disadvantage that installation complications make it difficult to obtain full sequence flexibility in all cases. To operate the schedule shown in *Fig.* 9 entirely by interval-timing units would require seventeen of them. However, to perform the cycle shown in *Fig.* 10 only four interval timers would be needed.

Schedules such as represented in *Fig.* 9 are conveniently regulated by a further adaptation of program timers into multiple-cam controllers like that in *Fig.* 5. The one shown in *Fig.* 6 would handle any three functions in the same diagram. Other modifications of drum-type controllers may be built with twenty or more stations to suit special problems. In this style of controller, it is possible to benefit fully by the ease with which coaxially mounted cams may be oriented at any desired angle relative to each other and to the starting position. Drums with screw-attached segments, such as shown in *Fig.* 5, are built for cycles requiring infrequent changes. The type shown in *Fig.* 6 is for more frequent variation and uses horseshoe-shaped segments in sets of five, providing a circumferential expansion of 5:1. If a change beyond this amount is needed, other sets may be substituted. The drum stack may be loosened, to permit removal, by sliding segments endwise on the short pilot diameter in the drum section and then radially over the shaft. Special cam contours can also be inserted as may be two-level cams for use in the manner of single-cam controllers.

Problem of changing the speed of the time-cycle controller has been a source of constant concern to manufacturers. Many ingenious devices have been developed with varying degrees of success in the effort to change speed by setting a pointer to a graduated dial. Because of stability or because of maintenance many are returning to straight gear changes or other methods of time-cycle control not involving cam rate changes. The slight additional trouble involved in changing gears may be more than offset by reduced service troubles. For frequent speedchanges quick-change gear boxes are convenient but involve higher equipment cost.



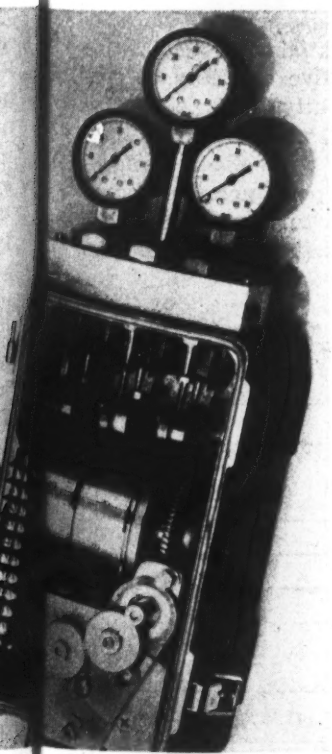


Fig. 7 — Right — Mechanical timer utilizes motor-driven, eccentrically mounted bearing to actuate switch through an adjustable-length striker

Many expedients have been employed for increasing the ease of adjusting the duration of events without concern about changes in cam rate. An important one is based on the "impulse-sequence" principle which has been applied in a variety of mechanisms of which the controller, *Fig.* 1, is an example. By combining a fixed-rate quick-resetting program timer capable of sending an impulse at desired intervals and a cam-indexing mechanism providing the necessary sequence flexibility, a high degree of operating convenience and flexibility is achieved. The attractive feature of this unit is that all adjustments of time and sequence may be made by selecting keys with-

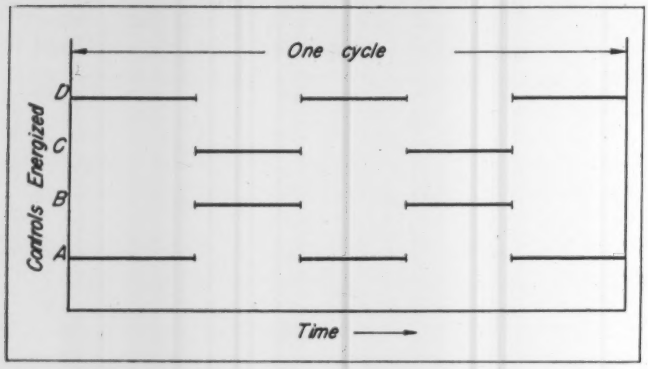


Fig. 8—Simple program schedule is achieved by paralleling components. Such cycles require few timing units

out removing or inserting parts, cutting or punching. The principal limitation of any impulse-sequence combination is the number of indexes possible on the sequence cam-shaft. For example, the diagram of *Fig.* 9 is complicated by the interruptions in function *B*. If this cycle could be rearranged by coinciding the start or stop of certain durations to reduce the indexes by five, the bumping could be dealt with from inside the instrument. Otherwise some form of external attachment provides the extra subcycles.

SIGNAL MEDIA: The system that provides the needed precision and flexibility with least immediate and ultimate cost is the logical choice. If a preference for limit or time control is not sharply defined by other requirements, time control has frequently proved the less expensive choice. In cases where limit control is to apply in one portion of a cycle but is to be rendered ineffective in some other part of the cycle, a time control may energize or de-energize sections of the limit control system through its pilot circuits and at the same time be available for the more accurate regulation of time-operated units.

Air is a Preferred Medium

Except in increasingly rare cases electric, air or oil are the preferred implements of control. Electricity and air are preferred in time control and hydraulic functions are controlled secondarily by electric or air signals from the timer. The selection of medium will depend upon availability, the nature of operation at the point of the signal pickoff and the nature of the control unit.

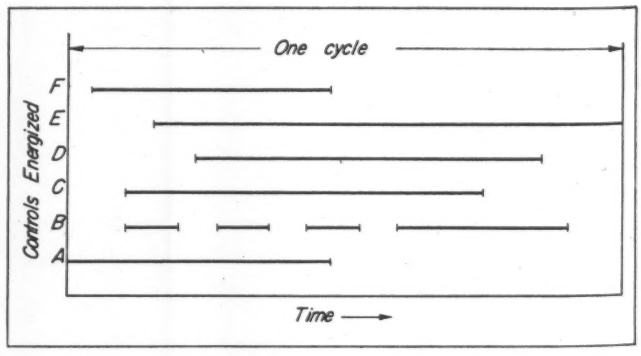
When compressed air is used, the low-pressure pneumatic signal has many advantages. It is clean, requires no return lines and is safe in the presence of hazardous atmospheres. Power loss in small signal lines is relatively low and powerful thrusts may be applied with the consumption of energy only during the power stroke. Associated equipment is inexpensive and may be installed by relatively unskilled personnel; pilot valves capable of handling useful flows require little operating force.

One of two signal pressures are customarily used. Many molding presses use a numerous array of air-actuated valves operating at 35 psi because of the smaller diaphragm dimensions required and because faster valve shifting is possible in on-and-off high-pressure hydraulic valves. Process industries, using many throttling valves under air operation, prefer 17-psi service in instances where speed is not so much a factor as light pilot-valve action. Air pilot signals are preferred whenever short, powerful thrusts are required without much damping such as in valve operation, clamping and tripping. They are also valued where small amounts of low-pressure air may be used directly, as in agitating, decanting or inflating, or where other functions would require it, for example, air-operated pressure or temperature controls which are to be cut in or out on a schedule. Where more rapid action and higher pressures are required, as for large cylinders, inexpensive air-operated relay air valves are available.

Electrical signals are possibly more widely used than air. When properly installed they are inherently safe but are considered a potential danger in combustible atmospheres under the best of installations. Power loss is low in the signal lines and conversion to mechanical power is efficient. The electrical signal is chosen when interval timers are to be used, or when it is desired to produce short, rapid thrusts at rates higher than practical with air or oil. It can be used to produce sustained rotary motion, magnetic, inductive, or capacitative effects, illumination, electric heating or direct application of potential. Many elements of associated equipment are relatively more expensive than those required to do the same job with air. However, sensitive pilot switches capable of handling one and two kilowatts of noninductive load are not expensive and require only a few ounces of force. Such switches, and synchronous timer motors have not been found readily available for service over 220 volts. Where higher power and voltage must be handled, commercial integral-horsepower motor contactors are available and satisfy most situations.

As a signaling means, the use of hydraulic pressure is more usually confined to limit controls where larger forces are available and speeds are relatively high, as on machine slides. It is inconvenient to use in proximity to the more sensitive elements of program control since it is inherently hard to confine completely. Signal impulses in small-diameter lines are not efficiently transmitted if appreciable displacement is required. Also they depend upon pressures upward from 100 psi. These, in turn, require higher operating forces at the pilot valves. However, the

Fig. 9—Schedule consisting of many dissimilar periods requires 17 timing units for control



higher pressures allow the use of small-diameter cylinders for valve and other thrust operations, an advantage when space is extremely limited. However, the incompressibility of the fluid provides damping in dynamically unstable situations with which air pressure cannot deal. Hydraulic systems using an oil or water medium are normally not hazardous, but oil, especially, should be kept away from unusually high temperatures and from oxygen. Cylinder-operated valves are now available for use where larger flows and pressures are to be handled from pilot circuits.

Various devices may be secured for the transfer of signals from one medium to another. There are hydraulically and air-operated pressure switches, hydraulically operated air valves and solenoid-operater air and hydraulic valves. With simplicity the criterion, the least number of stages of conversion necessary between the limit-signaling device or the timing instrument and the operating unit should be sought. It is for this reason that time-cycle control manufacturers build their instruments to handle air valves of considerable capacity, such as most of those illustrated. The advantage in eliminating the extra step of a solenoid valve between the timer and a pressure-operated valve or other pressure-operated device is obvious.

CONTROL: The details of a program-control installation will depend a great deal on its purpose. For quality control, any of the operations of the process may be left under the command of the operator with only the critical conditions instrument governed. An example is a plastic-molding operation where the operator has complete command of the movements of the press until the molds close. At this point a limit switch starts an interval timer, the manual controls are overpowered and the timer times out the cure and opens the press. For production control all the operations may be locked up after setting the fully automatic control. Where operators may be required to vary a time cycle, such as might be desired in an industrial laundry, the automatic controls may be accessible to the operator.

For job simplification, in cases of cycles that are not critical but involve groups of manipulations that must be accomplished in correct sequence and with the sequences varying from point to point in the cycle, the drum-type time-cycle controller is particularly suited. With the correct series of sequences set up on the drum not unlike the pins in a music box, and with the motor-control station set up to stop the drum the number of times required, the operator has only to push the starter button at the necessary moments in the progress of the cycle.

Because momentary contact from a pushbutton may be too brief to get the internal motor-control switch up on a cam, a starting solenoid is specified. This provides latching of the motor-switch station until the cam picks it up and may also operate the first external operating unit so that time shall not be lost while the drum is bringing up the first lobe. Special cam and switch provisions may need to be specified in drum types and in impulse sequence types when more than one start in a cycle is expected. When manual control is also provided, emergency situations and setting up of the process can be handled by the manual controls. However, when automatic control is supplied with no accessible manual control, safety requires that some means be provided so that in an emergency the operator can force the process equipment to a safe condition.

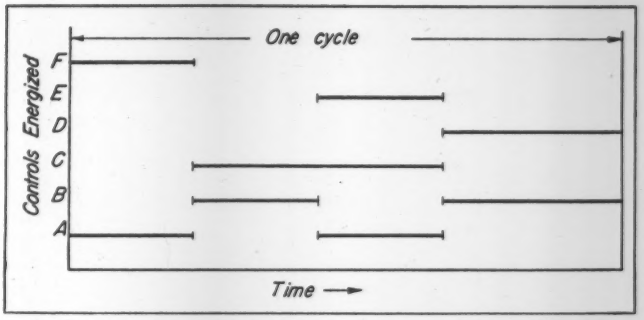
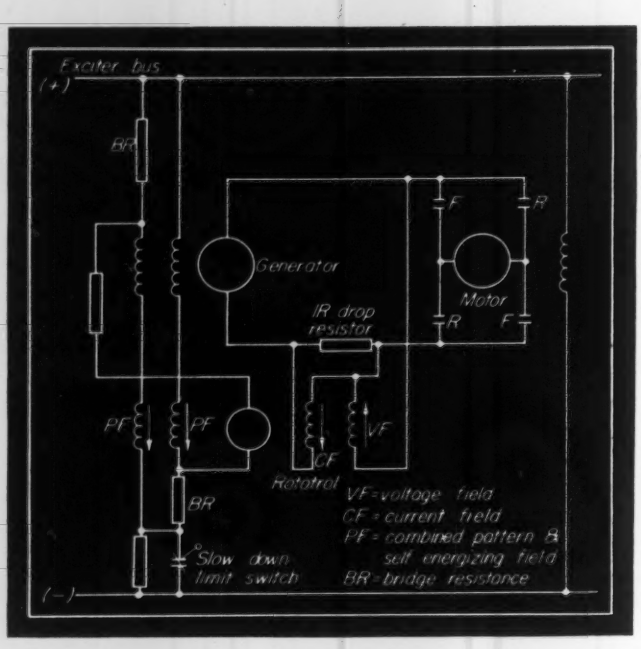


Fig. 10—Simplified version of schedule shown in Fig. 9 has several intervals of equal length, consequently, only four timing units are required

On the score of safety, power-operated processes, whether automatic or not, should be so arranged that in the event of the failure of any of the sources of energy, it will "fail-safe". That is, it will proceed to a condition which is likely to do the least harm—first to personnel, second to equipment and finally to material in process. As examples, air or electrical failure in a plastic-molding press installation should open the press; in a pressure and temperature process, power failure should remove enough heat supply to prevent possible explosion. Therefore, one excellent safety provision for use with fully automatic controls is to remove pressure or voltage from the system with a valve or switch enclosed in a locked box. This may be operated by a pull chain so that supervision must be notified before production can proceed.

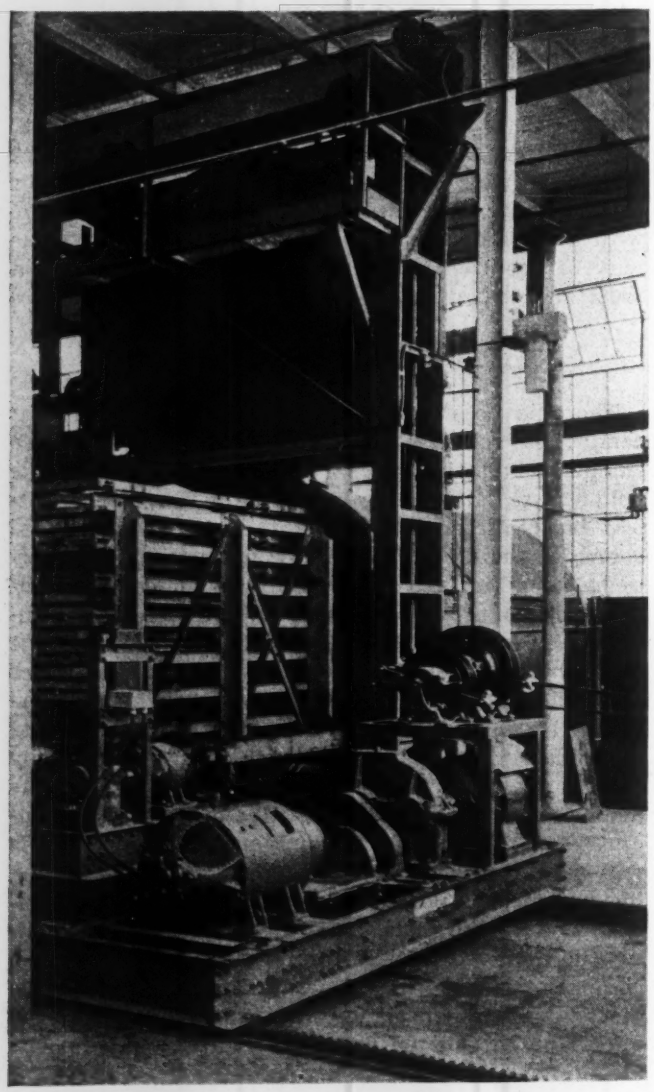
Standard Units Have Advantages

There is no mystery about program control that cannot be solved with a little careful study. To enumerate all the "tricks of the trade" would take volumes, so it is better to outline a few of the critical basic factors and leave the rest to individual common sense. Although a manufacturer may try to be an all-inclusive source of the components contributing to program control he cannot do so completely because the field is too broad. However, he can provide a detailed coverage of certain branches of application based on the fields into which opportunity has led him. Therefore, the designer having a problem may find a source of willing counsel by shopping around and accumulating the suggestions most pertinent to his needs. There is one safe generalization: The engineer applying program controls will save time and money in the long run by relying as much as possible on equipment already developed and on the market. In novel and special applications, it is worthwhile to find out whether existing equipment may be modified satisfactorily. With this disposed of, the designer may concentrate his best efforts on the unique phases of his project which he alone knows better than anyone else.



Assures Accurate Positioning

By A. T. Bachelor
Industrial Engineering Dept.
Westinghouse Electric Corp.
East Pittsburgh, Pa.



VULCANIZING air foam rubber cushions by the oven method introduces the problem of handling molds containing the uncured rubber foam. These molds must be handled with dispatch and without bumps or jars which might cause the foam to collapse. The Goodyear Tire & Rubber Co. has in operation a material-handling system involving conveyors, elevators, and a transfer car.

The transfer car receives a stack of filled molds from one elevator, the molds being pushed into a cage on the transfer car. The car then moves along a track in front of the battery of ovens to the position for charging an empty oven. The next operation is moving the stack of molds into the oven, the cage being extended to bridge the gap between transfer car and oven. Further handling of the rubber is done after the vulcanizing is complete and involves the same operations but in the reverse order.

Two exacting requirements of the transfer car drive are that starting and stopping shall be smooth and that the stopping shall be accurate. The accurate stop is necessary in order to minimize jolts due to improper lineup of the cage with the elevator or one of the ovens. The motion of the molds into the oven by the cage also requires smooth starting and stopping.

In order to maintain the accuracy of stopping, the drive for the transfer car slows down to a stable creeping speed from which a spring set magnetic brake brings the drive to a stop. The creeping speed has to be definite and must not vary widely with change in load on the drive.

The solution to this drive problem is an adjustable voltage d-c drive with a Rototrol speed regulator for both the transfer carriage and the cage. This combination provides the smooth acceleration and de-

(*Concluded on Page* 180)

MACHINE Editorial DESIGN

No Time To Waste!

Billions of dollars for defense equipment, stockpiling of materials, and plans for drafting manpower, all are indicative of the determined efforts being made to maintain world peace while being fully prepared for any emergency. Such activities show definite acceptance of the fact that the only way to keep the peace in the face of aggression is to be ready for war. No more pertinent proof of this axiom could be found than the willingness with which advantage was taken of our unpreparedness in each of the last two world conflicts.

Co-operation of industry with the Government is absolutely essential if the current defense program is to be successful. Much of the time and effort that have so capably been devoted to reconversion from production of wartime goods to a peacetime economy must necessarily be applied to the formulation of plans for meeting another potential emergency. Every machine manufacturer in the country not now working on Government contracts can help in this respect. Immediate surveys, for instance, should be made by each individual company to check its facilities and determine a course of action which would enable it to turn over swiftly to production of war materiel in case of need.

Research, development and design—vital factors in the last war which would be even more important in case of another—could well be placed on a still higher plane and given greater emphasis. That this is recognized is evidenced by the increasing collaboration between industry and many of the universities. More and more grants are being made to the colleges by large corporations to enable research work to be carried out. While such work is aimed primarily at peacetime developments, the results would be invaluable in the event of another world crisis.

Engineers responsible for design earned an enviable reputation in World War II. Since the cessation of hostilities they have utilized their abilities in the development of machines capable of maintaining the rate of national progress in the face of numerous labor disturbances and rising costs. There could be no better time than now for them to fulfill their traditional role—that of anticipating requirements and being capable of creating new developments which, whether for peace or preparedness, cannot be surpassed.

L. E. Jerry

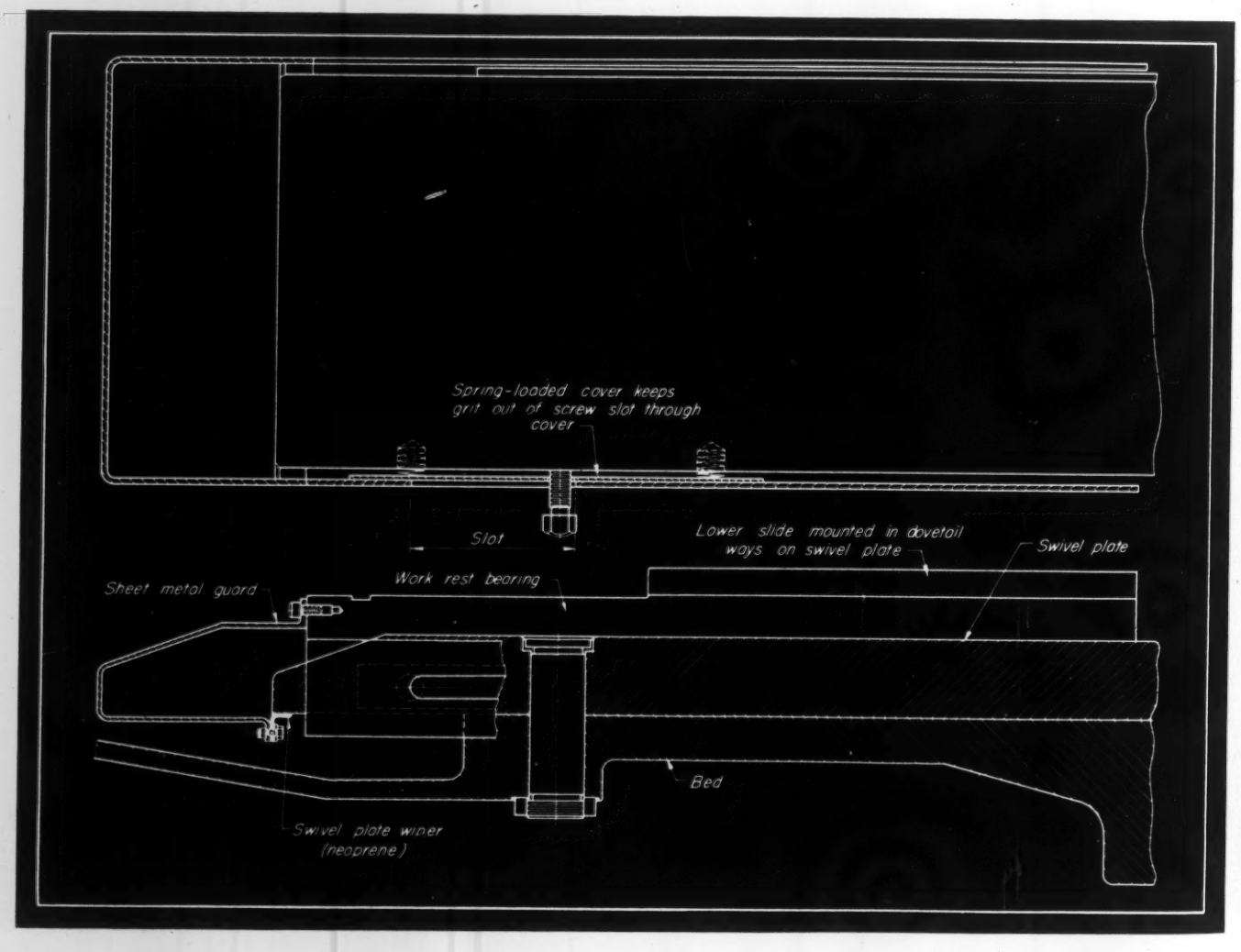
DESIGNS OF THE MONTH

Centerless Grinder Ways Protected by Simple Design

SLIDE ways of the centerless grinder, top, next page, are effectively protected from grit and coolant by a guard of extremely simple design. As can be seen in the top view of the cross section drawing, below, function of the spring-loaded cover plate is to stop grit, coolant, or other matter, from entering through the slot which provides clearance for movement of the screw. Another simple and practical means of sealing employed on this machine is the neoprene wiper shown in the lower view of the drawing.

Units supporting the regulating wheel housing are mounted on an intermediate plate which has a swivel adjustment through a trunnion mounting on the bed. A large handwheel, with graduated dial, adjusts the upper and lower slides in relation to each other, or as a unit when they are clamped together.

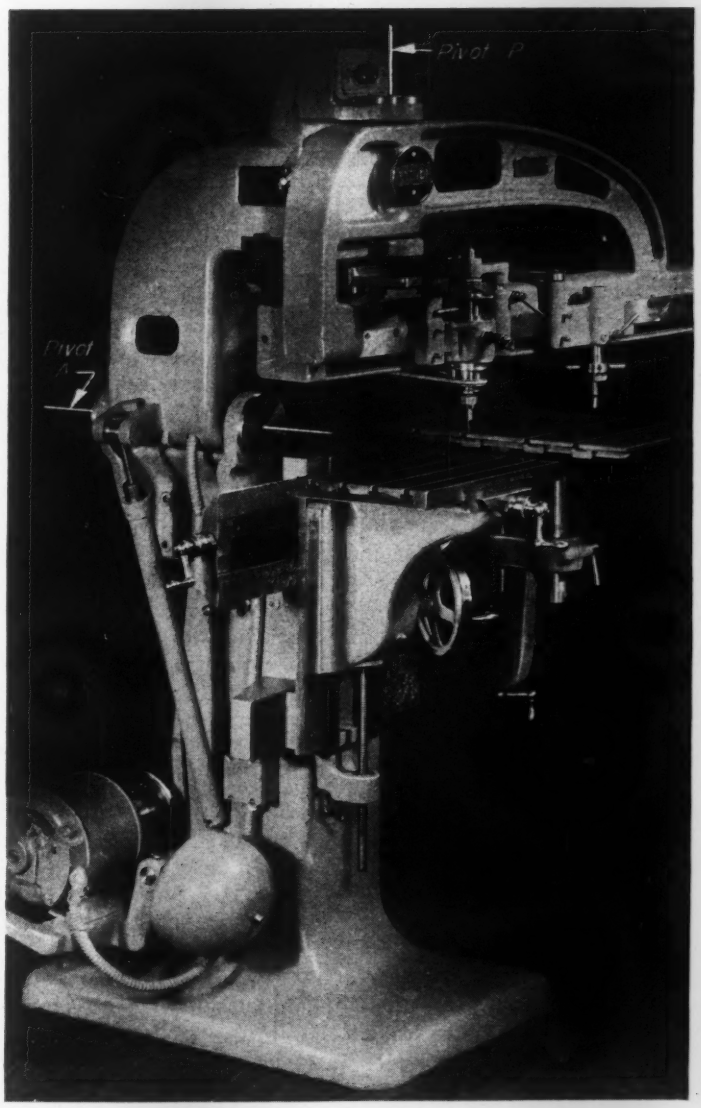
Both the grinding-wheel and regulating-wheel spindles are automatically lubricated and mounted on multishoe bearings. These bearings consist of segments or shoes,


Spring-loaded cover keeps grit out of screw slot through cover
Slot
Lower slide mounted in dovetail ways on swivel plate
Swivel plate
Sheet metal guard
Work rest bearing
Bed
Swivel plate wiper (neoprene)

pivoted to allow the entrance of wedge-shaped oil films which develop high pressures between the segments and spindle. The multiple, high-pressure oil wedges constitute a "fluid vise" which maintains accurate dead-center rotation of the spindle under any load developed. A pressure switch in the grinding-wheel-spindle lubricating system automatically stops the main drive motor if the oil pump fails.

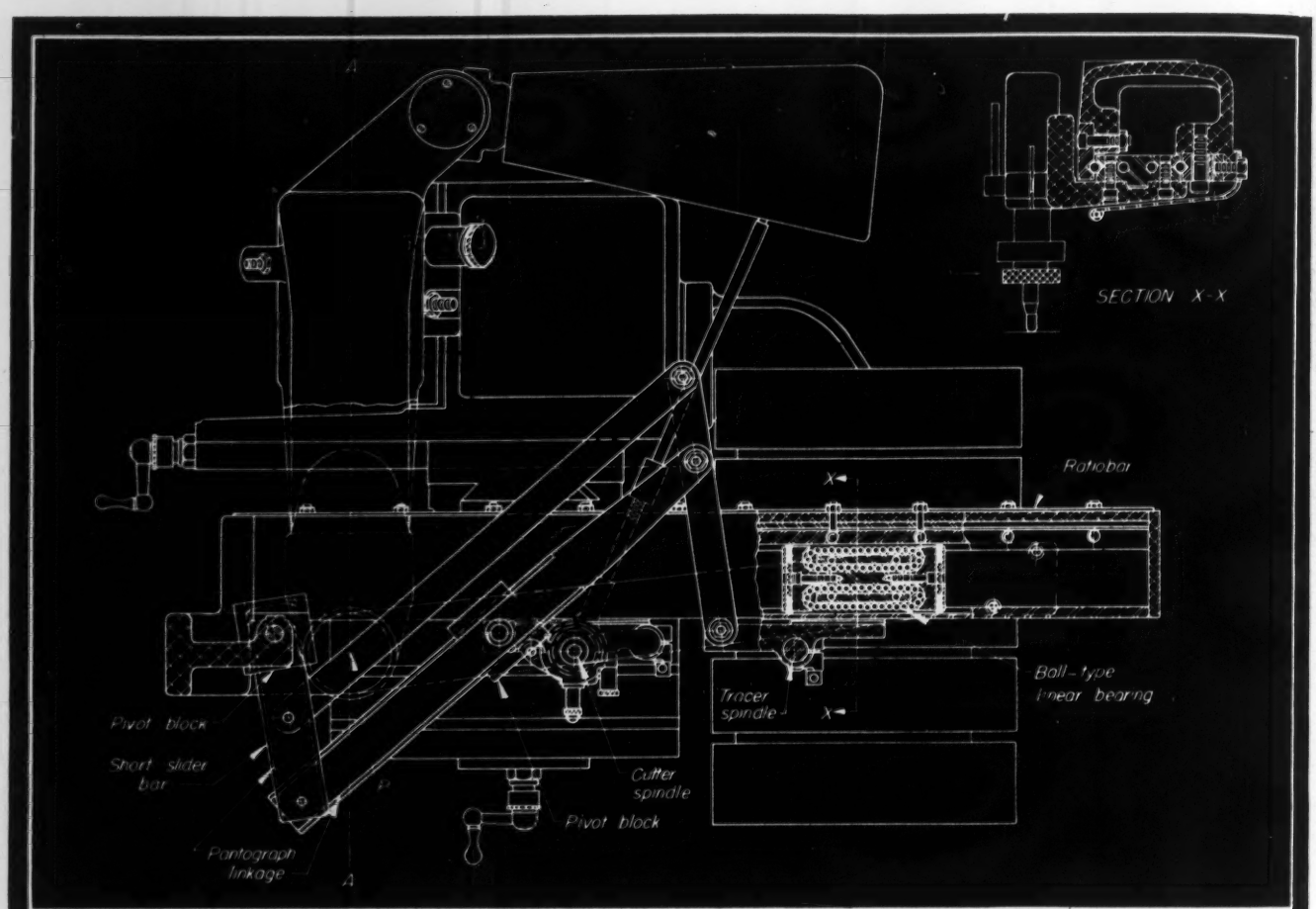
Electrical controls are built-in and protected by a hinged cover at the front of the machine. The latch handle of this cover constitutes an externally operated disconnect switch, interlocked so that current is automatically shut off when the cover is opened. The oil-tight pushbuttons operate at 110 volts through a transformer.

Straight hydraulic grinding-wheel truing is employed, with arrangement for cam-controlled profile truing, if desired. The regulating wheel truing unit is manually operated, screw-propelled. However, it can be replaced readily with a hydraulically operated unit arranged for profile truing. Regulating wheel speeds are changed by lever-operated sliding gears. Twelve speeds are available, from 12 to 300 rpm. Mfr: Cincinnati Grinders, Inc., Cincinnati 9.



Three-Dimensional Pantograph Employs Novel Ratio Bar

COMBINATION of a "Ratiobar" and a four-bar pantograph linkage with tracer and cutter spindles carried on ball-type linear bearings, makes the three-dimensional pantograph machine, right, extremely accurate, sensitive and easy to set. The Ratiobar is used to set the ratio of reduction in a vertical



plane and in one dimension of the horizontal plane when pivoting about centers *A-A* and *P* respectively. A relatively lightweight four-bar pantograph linkage of conventional design provides the proportional movement of cutter spindle to tracer spindle along the axis of the Ratiobar. By a unique location of this linkage reductions to infinity are attained.

Linear movement of the tracer and cutter heads on the Ratiobar require a smooth-acting, shake-free bearing. A ball-type linear bearing operating on hardened and ground steel races with two continuous chains of balls under preload meets these demands.

Inasmuch as the cutter head and tracer head races are integral parts of the Ratiobar, the cutter, tracer and pivot *P* centers always move along a common straight line. This arrangement permits single-point ratio setting, i.e., loosening gib plates on the pivot blocks and sliding the cutter head along the Ratiobar until an index point on the cutter-head pivot block is coincident with the reduction setting desired on the graduated pantograph bar. Since a true parallelogram is maintained by the pantograph linkages at all times, the short slider bar automatically positions itself in its pivot block. Both pivot blocks then can be secured and the ratio is set.

The Ratiobar is hung from a cast overarm of I section in such a way that the pivot *P* extends above, and its centerline intersects the common line joining the cutter and tracer centers. A third cast member supports the overarm and Ratiobar assembly on pivot *A* at right angles to pivot *P*. Rotation of the entire assembly about pivot *A* provides the movement for the third dimension. Manufacturer: George Gorton Machine Co., Racine, Wis.

Temperature Controlled Electronically in Automatic Flame Hardener

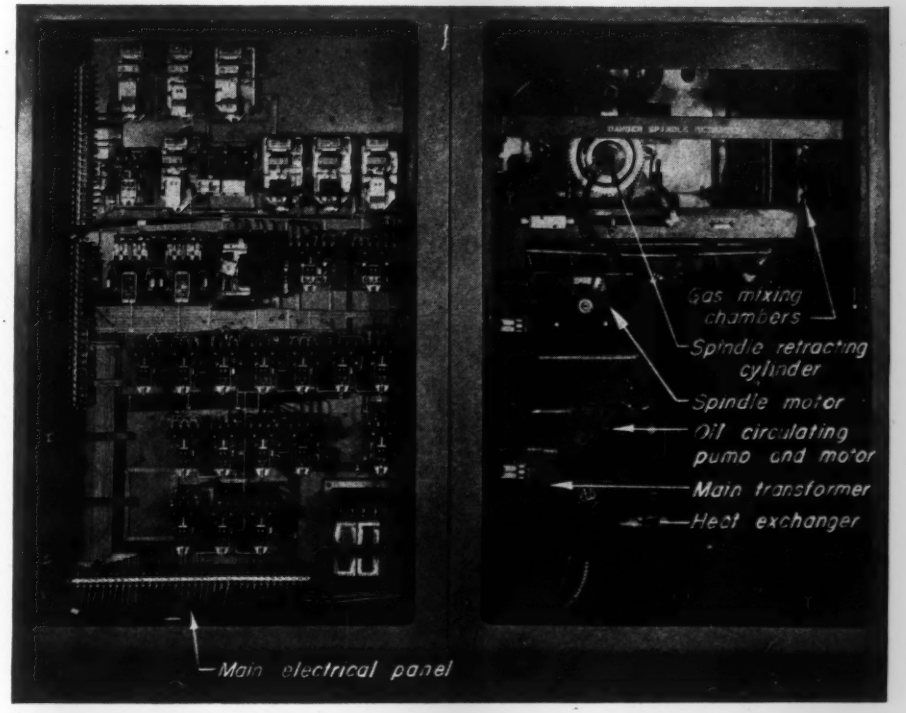
USED to flame harden machine parts automatically, the Flamatic machine, bottom, next page, basically consists of a work table built over a conveyorized quench tank, flame head assemblies adjustably mounted on the work table, and a spindle, to which a work-holding device is attached, centered between the flame heads.

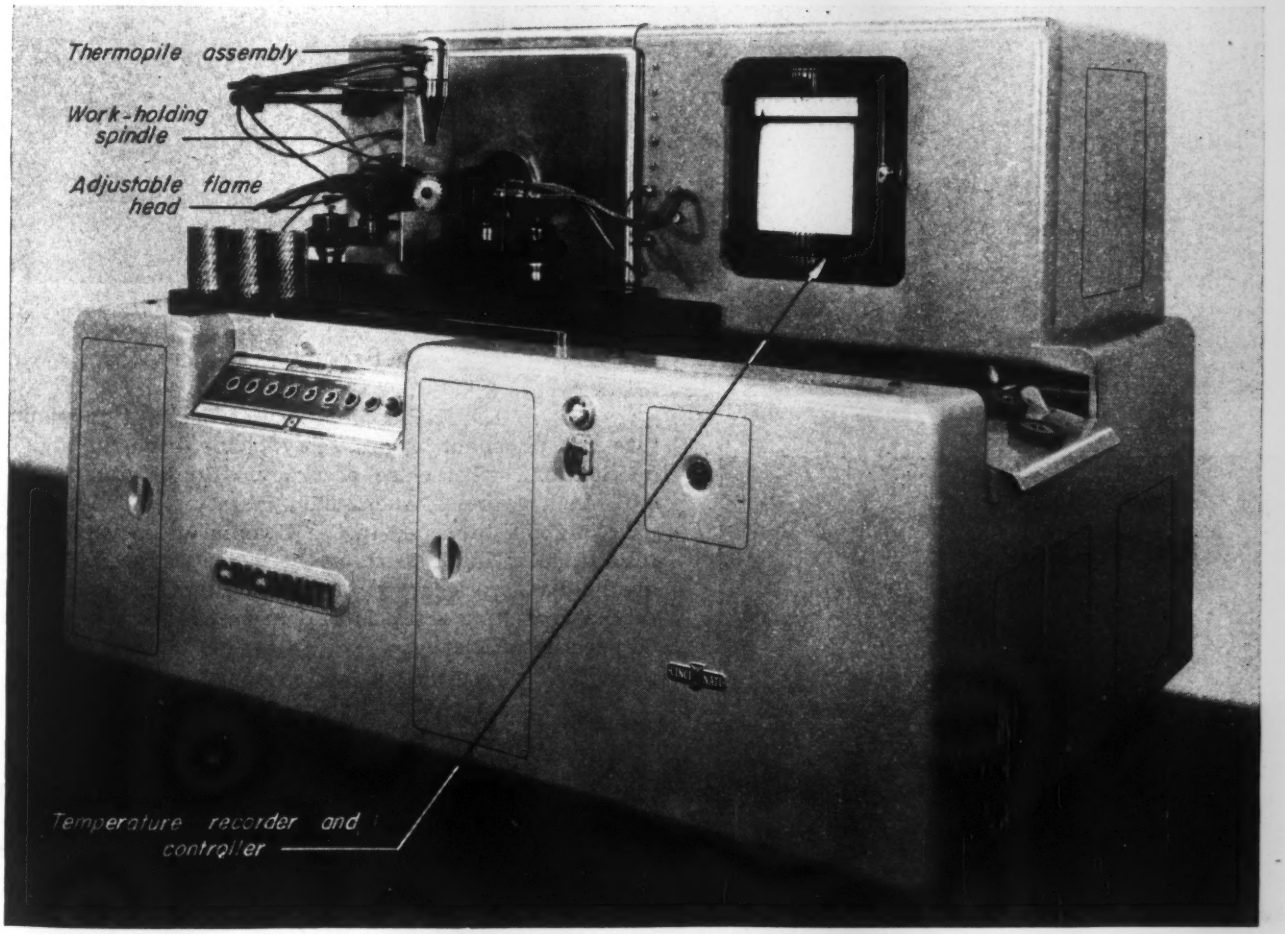
In operation, the workpiece is placed manually on the holding fixture, and a cycle-start button is pressed, initiating the following automatic cycle: The spindle starts rotating, the flames are ignited, the surface of the workpiece is heated to a preset temperature, the flames are extinguished, and the spindle stops rotating and retracts, stripping the workpiece off the

holding fixture and into the quench tank.

Most important feature of the machine is its electronic temperature-control system. A highly sensitive thermopile is focussed to receive radiant energy from the rotating workpiece during the heating cycle. The emf generated thereby is transmitted to a temperature recording and controlling instrument which, when the preset temperature is reached, controls the remaining operations of the cycle through actuation of electrical relays and a solenoid-operated air valve and air cylinder.

The conveyor in the quench moves a preset distance at the beginning of each cycle, clearing a space to receive each piece and insuring against damage to parts in the quench. Processed parts are delivered by the conveyor to a takeoff plate at the end of the machine where they may be collected or picked up by another conveyor. Manufacturer: Cincinnati Milling Machine Co., Cincinnati 9.



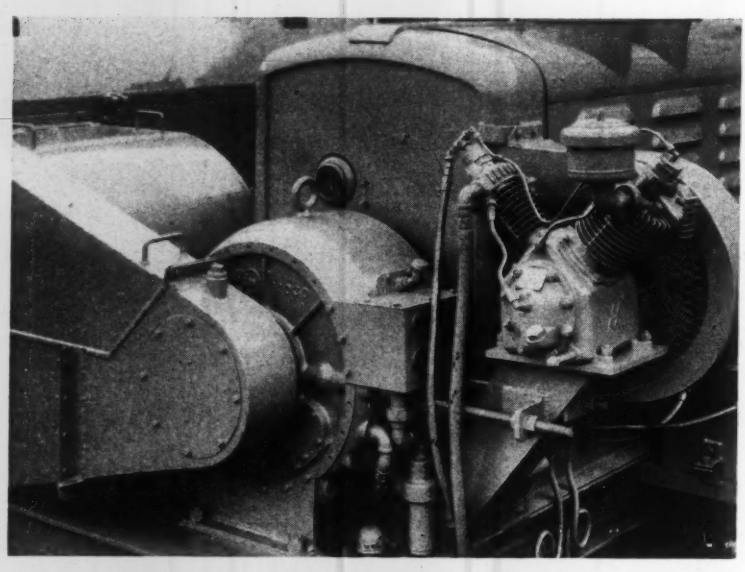


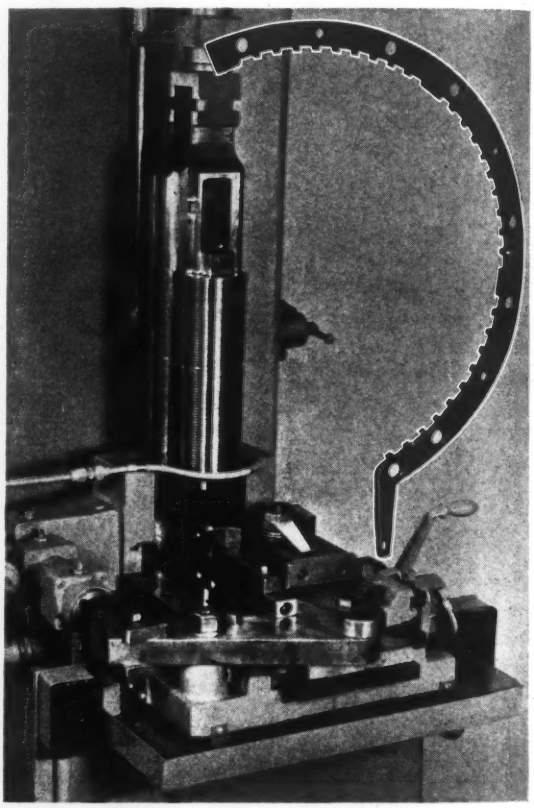
Applications

of engineering parts, materials and processes

Handles Heavy Loads

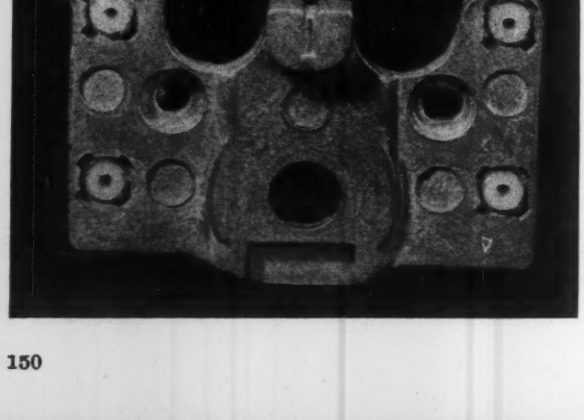
HAVING high efficiency and ability to handle heavy loads smoothly, Torcon hydraulic torque converter is used in the Wagner-Morehouse oil-well hoist shown below. Hoist is used to remove rods and tubing from wells in order to make necessary repairs. In each instance several thousand feet of tubing must be lifted from the well. Use of the torque converter between the engine and the hoist permits raising strings of tubing weighing up to 150,000 pounds easily and rapidly.





Broaches Relay Part

SURFACE broaching is used to manufacture the phosphor-bronze relay part, above, in high production and with close accuracy. Rough-stamped about 0.015-inch oversize, the 2-inch diameter, 0.064-inch thick part is stack broached in the Colonial 6-ton vertical press illustrated. The 31 teeth on the inside surface of the parts are held to an accuracy of 3 minutes of arc. Production of the broaching setup is said to be 360 parts per hour at 85 per cent efficiency.



Withstands Staking

NYLON bushings for tuning device bracket, left, are machined from rod, staked in place and then tapped. While previously used materials often broke in the assembly operation with resultant high scrap loss, the resiliency and toughness of Nylon withstands the impact of staking, decreasing production costs.

Calculating Deflections of Hollow Shafts in Torsion

By Carl P. Nachod
Vice President
Nachod & United States Signal Co. Inc.
Louisville, Ky.

DIMENSIONS of a tubular shaft to meet specific stiffness requirements are readily calculated with the aid of the accompanying nomogram. Use of the chart obviates solution of the fourth-power equation which the conventional formula solution involves. Fundamental formula for the deflection or twist under load of a tubular shaft is

$$\theta = \frac{TL}{GI}$$

where

θ = Angular deflection (radians)
T = Torque (lb-in.)
G = Torsional modulus
= 11,000,000 psi for steel
I = Polar moment of the tubular section
$= \frac{\pi}{32}(D^4 - d^4)$
D = Outside diameter of shaft (in.)
d = Inside diameter of shaft (in.)
L = Length of shaft (in.)

Substituting for G and I and reducing

$$\theta = \frac{TL}{(D^4 - d^4)\ 1.08 \times 10^6}$$

The nomogram on the next page solves this equation. If G is taken as 11,500,000, the constant 1.08 becomes 1.13.

To use the nomogram to find T, draw Secant line I through the inner and outer diameters, d and D, (2 and 2.2, for example) extending it toward the left. Draw Secant II through θ (=0.3) perpendicular to Secant I, prolonging it to cut Q, the turning scale. Through this intersection and through length L (=40) draw Secant III, prolonging it to cut T (at 60,000 lb-in.) the required torque.

To find d, draw the secants in the reverse order III, II, I. A series of parallels to Secant I will give an infinite choice of corresponding values of inside and outside diameters which will satisfy the conditions of the problem. For convenience a degree scale is drawn alongside the radian scale.

The chart is made up of a right angle and two parallel lines, with a Z-chart at the bottom. To save time, Secants I and II can be drawn as "cross-hairs" on transparent material.

For those desiring to construct a similar chart for other ranges the following relations hold true for the various scales:

Angle scale, θ, modulus is $m_\theta = 10$ (1 inch = 0.1 radian = 5.729 degrees).

Diameter scale, D, modulus in $m_D = 0.075$ length from zero to any point D is $0.075\ D^4$). The same relation holds for the d scale.

Torque scale, T, modulus is $m_T = 10^{-4}$ (1 inch = 10,000 lb-in.).

Turning scale, Q, modulus is $m_Q = 1.2$ (no graduations needed).

Length scale, L, is such that the distance from zero to any point L is given by the relation

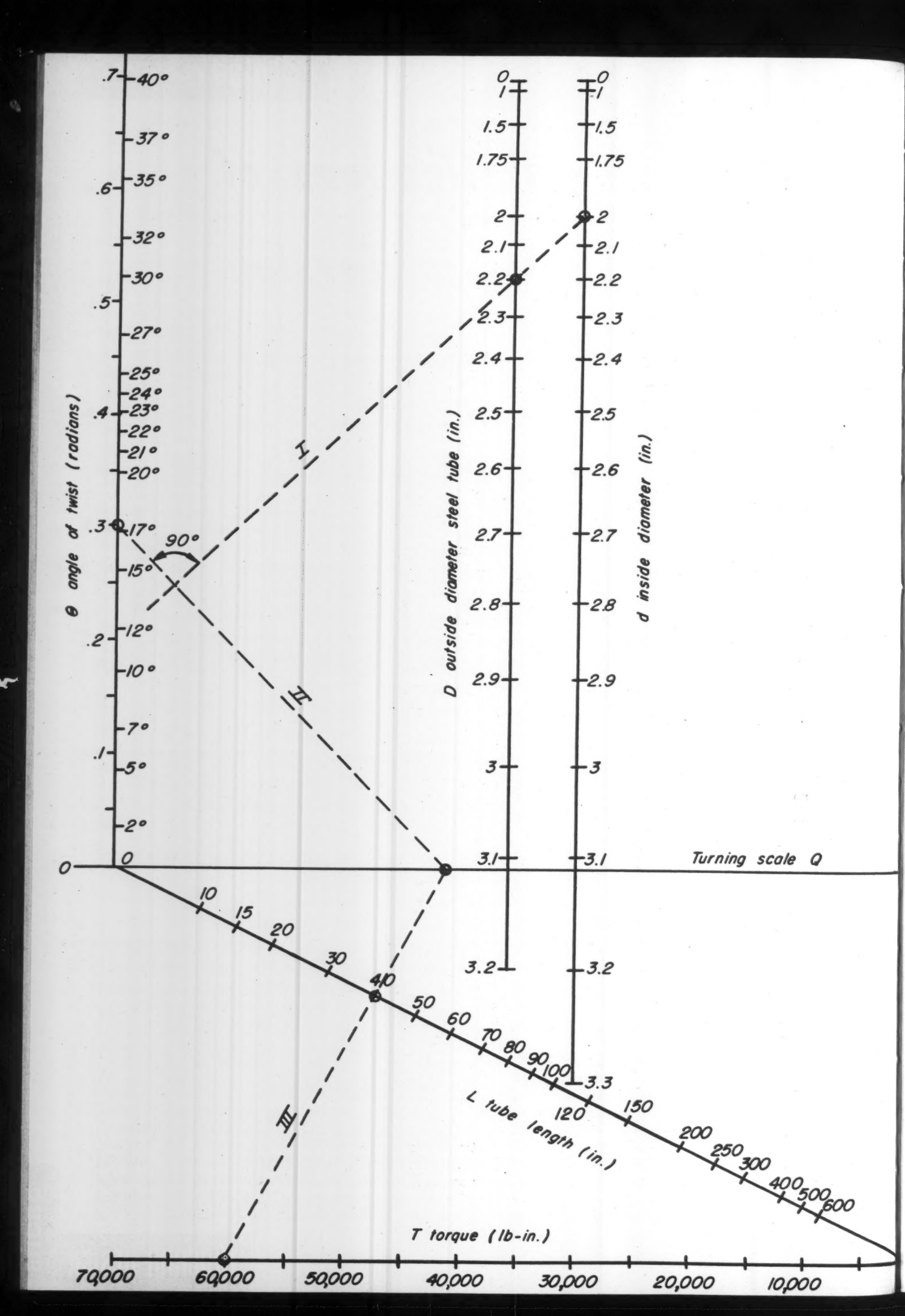
$$\frac{9.37\ L}{1.2L + 100}$$

Spacing of scales θ, D and d is not restricted, but the zero of graduations of the D and d scales must be on the same level. The distance k between the D and d scales must be such as to satisfy the following relation:

$$m_\theta = \frac{m_Q k}{m_D}$$

Using the values of the moduli already established, the distance k from this relationship is 0.625-inch.

Since the chart involves fourth powers it must be accurately drawn; its accuracy increases as the range of variables decreases. A table of fourth powers is convenient in constructing the chart.


θ angle of twist (radians)
.7
40°
37°
.6
35°
32°
30°
.5
27°
25°
24°
.4
23°
22°
21°
20°
.3
17°
15°
.2
12°
10°
7°
.1
5°
2°
0
90°
I
II
III
D outside diameter steel tube (in.)
0
1
1.5
1.75
2
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3
3.1
3.2
d inside diameter (in.)
0
1
1.5
1.75
2
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3
3.1
3.2
3.3
Turning scale Q
0
10
15
20
30
40
50
60
70
80
90
100
120
150
200
250
300
400
500
600
L tube length (in.)
T torque (lb-in.)
70,000
60,000
50,000
40,000
30,000
20,000
10,000

Assets to a Bookcase

Magnetic Control of Industrial Motors

By Gerhart W. Heumann, control engineering division, apparatus department, General Electric Co.; published by John Wiley & Sons, Inc., New York; 589 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$7.50 postpaid.*

Basic work on motor controllers, this book will be a valuable addition to the library of any design engineer concerned with electric-powered machines. It is written entirely from the viewpoint of the engineer concerned with control application, and covers performance, characteristics of motors, characteristics of control devices, and the function of fundamental control circuits. Emphasis is placed on considerations governing the selection of controllers to perform specific jobs and various frequently used designs are discussed in some detail.

Among the chapters that will be of particular interest to designers are those on: Contactors and relays, pilot devices, electronic devices, basic control circuits, and intermittent-duty controllers. Numerous formulas are developed; drawings and charts are used to clarify many discussions while other data are presented in tabular form.

□ □ □

Powder Metallurgy

By Dr. Henry H. Hausner, consulting engineer; published by Chemical Publishing Co. Inc., New York; 298 pages, 5½ by 8½ inches, clothbound; available through MACHINE DESIGN, *$7.00 postpaid.*

A reference book rather than a text, this volume presents in compact form a wealth of information on powder metals and powder-metal parts. It has been the intent of the author to give, wherever possible, information in the form of tables and graphs. In this he has admirably succeeded; virtually all of the data is extremely accessible.

The book covers the subject of powder metals from production of the powder to properties of the sintered parts. However, of particular interest to the design engineer will be the sections on powders and their applications, the comparisons of sintered and cast alloys, and the effect of variables—pressure and particle size, for example—on physical properties of sintered parts. A 93-page bibliography included at the end of the book will be of great value to those desiring to explore the subject in greater detail.

Falk's Solutions

By Karl H. Falk; published by Columbia Graphs, Columbia, Conn.; 400 pages, 6 by 9 inches clothbound; available through MACHINE DESIGN, *$6.00 postpaid.*

This volume is a collection of data presented entirely in graphical form. To simplify use, all graphs have been constructed so that only straight-line connections between points are necessary for solution of a problem.

The general fields covered are mechanics, hydraulics, electricity, simple structures, physics, area and volumes, trigonometry, weights and measures. The total number of charts is about 400. While no advanced data are given, the book should be valuable as a general reference, providing such information as section moduli of shafts, speed of gears, angular speed vs. peripheral speed and areas of geometric sections.

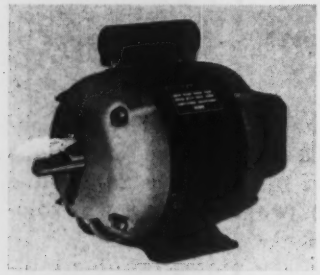
Newly prepared American Standard Z32.12-1947 covers symbols used in the electrical field, supplementing Standard Z32.11-1944 and providing 152 basic symbols which may be used on diagrams to describe electrical-circuit components. Among the classes of symbols covered are those used in electronic, thermionic and cold-cathode fields, as well as those used in straight a-c and d-c design. The standard is entitled "Basic Graphical Symbols for Electrical Apparatus." Paperbound, it measures 7¾ by 10¾ inches and contains 14 pages. It is available at 40 cents from the American Standards Assoc., 70 E. 45th St., New York 17.

Extensive compilation of data on the application of austenitic stainless steels has recently been published under the title "Forming of Austenitic Chromium-Nickel Stainless Steels." Authored by two of the outstanding authorities in the field of physical metallurgy—V. N. Krivobok and George Sachs—the volume presents a detailed description of the modern forming procedures as practiced in the United States. Bending and straight flanging, forming of curved sections and tubing, deep drawing, die forming and forming of contoured flanged parts are some of the subjects discussed. Clothbound, the 309-page, 8½ by 11-inch book is available at $4.00 from The International Nickel Co. Inc., 67 Wall St., New York.

new parts and materials

For additional information on these new developments see Page 253

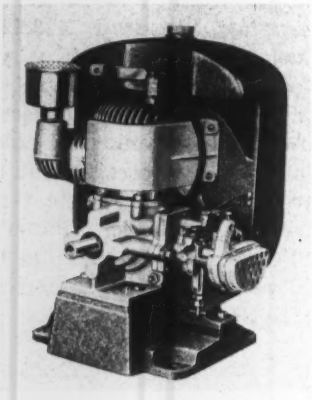
Fractional-Horsepower Capacitor Motors



Three sizes comprise the Triad line of single-phase capacitor motors. These 1725 rpm motors, built in ratings of ¼, 1/3 and ½-horsepower, are designed for 115 - 230 volt, 60-cycle, continuous - duty operation. Features of the new units include use of magnesium for end bells, all welded rotors, sealed spring-loaded bearings, and heavy welded-steel frame. Breakdown torques are: 26-32 oz-ft, for the ¼-hp unit, 33-42 oz-ft for the 1/3-hp unit, and 43-60 oz-ft for the ½-hp unit. Manufacturer: Triad Engineering Corp., 2414 S. La Salle St., Chicago 16.

For additional information circle MD 1 on page 253

Two-Cycle Gasoline Engine



Air-cooled 2-hp engine has aluminum-alloy housing and a horizontal crankshaft. Equipped with a hot-spark magneto, precision built carburetor and automatic governor, this model HE-842 engine is recommended for use in powering pumps, small tractors and light portable equipment. Manufacturer: Propulsion Engine Corp., 7th and White Eagle Road, Kansas City 15, Kansas.

For additional information circle MD 2 on page 253

High-Pressure Lubrication Fittings

Improved Kleenseal Bullneck type of grease fittings are now made in a wide range of sizes and styles. New units combine most of the desirable characteristics of former types and permit standardization. Among the features are: Ball in head design, keeping dirt out and facilitating cleaning; enlarged neck size and projecting locking pad to protect against damage and wear; special spring design to eliminate flow restriction of the heaviest lubricants; and large internal diameter, permitting large flow of lubricant. Manufacturer: Lincoln Engineering Co., 5701 Natural Bridge Ave., St. Louis 20.

For additional information circle MD 3 on page 253

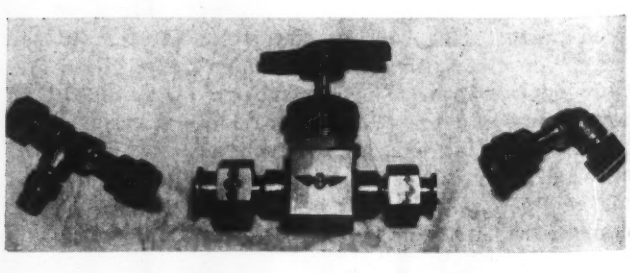
Heavy-Duty Snap-Action Foot Switch

Streamlined, heavy-duty foot switch is enclosed in a cast case, gasketed for oil-tight applications. Switch is compact and hugs the floor to prevent tipping. Wide and accessible pedal may be operated from both sides as well as the front, but is protected against accidental contact or falling objects. The new unit has adjustable stroke; short motion and slight angle are said to eliminate ankle fatigue. Contact arrangements available are: Single-pole, double-throw; double-pole, double-throw; and two stage (each stage being single-pole, double-throw). Switch is of the snap action type. Two interchangeable covers can be had, one with a pedal guard to protect the pedal against accidental operation and the other a plain cover for applications not involving hazard to the operator. Manufacturer: Industrial controller division, Square D Co., 4041 N. Richards St., Milwaukee 12.

For additional information circle MD 4 on page 253

High-Pressure Shut-Off Valve

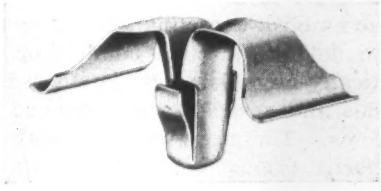
Featuring induction-brazed joints which will withstand 20,000 psi without leaking, newly designed shut-off valve is intended for use in systems having pressures up to 5000 psi. Unit utilizes couplings



rather than threaded joints for joining. Since couplings are flush mated, valve can be removed or installed in system without disturbing adjacent piping. Only finger tip control is needed to turn handle and, owing to large porting, pressure drop across valve is low. Manufacturer: Greer Hydraulics Inc., 454 18th St., Brooklyn 15, N. Y.

For additional information circle MD 5 on page 253

Push-In Snap Fasteners



Requiring no thread or special receptacles for secure holding, line of push-in snap fasteners are stamped from spring steel and form a resilient, vibration-resistant lock to hold sheets, panels and brackets in place. Extended prongs, formed as an integral part of the fastener, compress as the unit is pushed into a punched or drilled hole. As they pass through, they spring out again to hold the assembly together under constant spring tension. Flexible in design, the fasteners can accommodate total material thickness variations of more than 1/16-inch. Manufacturer: Shakeproof Inc., 2501 N. Keeler Ave., Chicago 39.

For additional information circle MD 6 on page 253

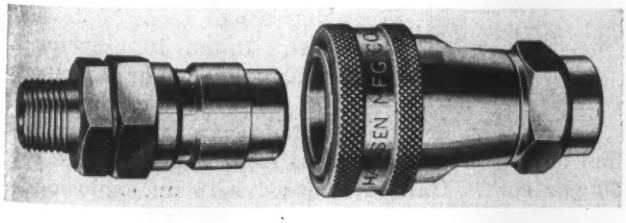
Wrought Bronze Sheet

Wrought from centrifugally cast billets, rolled aluminum bronze sheet is sound, flaw-free and uniform. No porosity, slag inclusions, pipes, striations or laminations are said to be found in the finished strip, sheet or plate. The material may be obtained annealed where corrosion resistance is important or unannealed and especially processed for applications where wear resistance is essential. Manufacturer: Ampco Metal Inc., 1745 S. 38th St., Milwaukee 4.

For additional information circle MD 7 on page 253

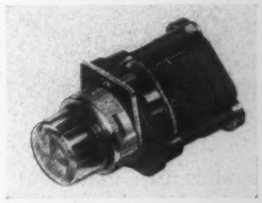
Hydraulic-Pneumatic Tube Coupling

Quick-connection coupling for either hydraulic or pneumatic lines is so designed that both members seal automatically when disconnected. Known as the series 8000 coupling, the unit contains valves in both socket and plug. Valves are opened automatically by inserting the plug into the socket. There is an O-ring seal between socket and plug when connected. Socket is available with ⅜, ½, or ¾-inch male or female pipe threads, hose stem or hose clamp connection. Plug is made with ⅜ or ½-inch male or female pipe threads, hose stem or hose clamp connections. Manufacturer: Hansen Manufacturing Co., 4031 W. 150th St., Cleveland 11.



For additional information circle MD 8 on page 253

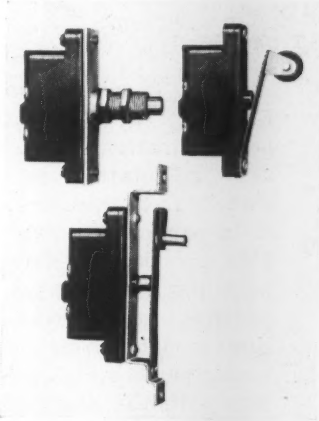
Oil-Tight Pilot Light



Designed for machine-tool application where cutting oils and coolants may result in the pilot light becoming inoperative, oil-tight pilot light is suitable for a wide voltage range. Unit is styled to augment a line of push-buttons and selector switches and is designed for panel mounting through a 1 7/32-inch diameter hole. Construction permits mounting on panels in the thickness range 1/16-inch to ¼-inch. Color caps designed for wide-angle visibility are available in clear, white, red, amber, green and blue. For a-c use, light has a built-in transformer, permitting use of a 6-volt incandescent lamp. The 6-volt filament is strong enough to withstand shock or vibration frequently causing failure of higher-voltage filaments. Manufacturer: Industrial controller division, Square D Co., 4041 N. Richards St., Milwaukee 12.

For additional information circle MD 9 on page 253

Actuators For Snap Switches

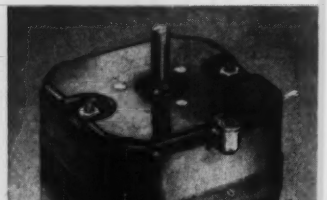


Made in three types, new switch actuators are designed for use with the Square D precision snap switch. Plunger type consists of a mechanism incorporating a brass tube within which is an operating button and an overtravel spring. Plunger is threaded on the outside and may be mounted on panels up to ⅝-inch thick by means of hex nuts. Hole ½-inch in diameter will accommodate the unit. Roller-leaf actuator consists of operating arm of beryllium copper on which is mounted a nonmetallic roller assembly. It is fastened to the switch housing by means of rivets. Door-type actuator consists of a beryllium copper arm assembled to a mounting bracket. Two mounting holes for fastening switch

assembly to door are provided in mounting bracket. Manufacturer: Industrial Controller Div., Square D Co., 4041 N. Richards St., Milwaukee 12.

For additional information circle MD 10 on page 253

Shaded-Pole Induction Motors



Raytheon type 300 motors combine high starting torque with high efficiency and flexibility. Made in ratings from 1/150 to 1/40-hp with starting torques as high as 10 oz-in., the units are available in open or totally enclosed construction. Either vertical or horizontal operating models are made for operation on 50, 50/60 and 60-cycle current at any voltage up to 250. Having self-aligning wick-fed Oilite bearings and large reservoirs the units are long lived and are designed to provide trouble-free operation. Manufacturer: Russell Electric Co., 340 W. Huron St., Chicago 10.

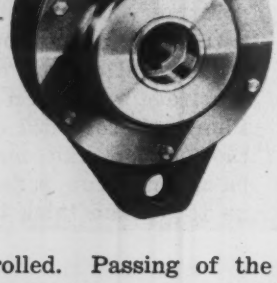
For additional information circle MD 11 on page 253

Cupro-Nickel Condenser Tube

Condenser tube of 88.5 per cent copper, 10 per cent nickel and 1.5 per cent iron has been developed to sell at a price comparable to that of aluminum brass. The tube is recommended for installations encountering high velocities, high temperatures and brackish or salt water. Manufacturer: Revere Copper and Brass Inc., 230 Park Ave., New York 17.

For additional information circle MD 12 on page 253

Mechanical Anti-Reversing Device



Device known as the Backstop provides a positive method of preventing rotating machinery from reversing. It is particularly suitable for use on such machines as conveyors, winches, etc. Operation is by means of heavy pawls which rotate with the shaft of the machine being controlled. Passing of the machine through the zero-acceleration point causes the pawls to wedge into their housing bore, immediately stopping all rotation. The Backstop is built in three sizes to accommodate a wide range of shaft diameters and torque loadings. Size 10 is designed for a maximum speed of 3600 rpm and 541 lb-ft maximum torque. It will accommodate shafts from ¾ to 1⅝ inches in diameter. Size 20, rated 2400 rpm and 1155 lb-ft has a minimum bore of 1 11/16 inches and maximum bore of 2⅛ inches; size 60 for 1800-rpm, 3360 lb-ft operation is bored 2 3/16-inches minimum and 3¾-inches maximum. Manufacturer: The Falk Corp., 3001 W. Canal St., Milwaukee 8.

For additional information circle MD 13 on page 253

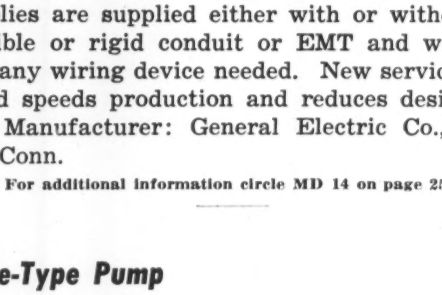
Electrical Conduit Assemblies

Made to manufacturers specifications, new conduit assemblies are supplied either with or without wire in flexible or rigid conduit or EMT and with practically any wiring device needed. New service simplifies and speeds production and reduces design problems. Manufacturer: General Electric Co., Bridgeport 2, Conn.

For additional information circle MD 14 on page 253

Turbine-Type Pump

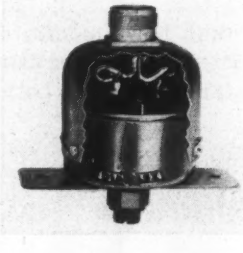
Having a capacity of 250 gpm, the Eagan turbine pump will handle clean liquids of viscosities up to 500 Saybolt seconds at pressures up to 200 psi. The



unit has been developed to meet requirements such as high heads at low capacities, high efficiencies and low speeds. It will handle nonlubricating fluids at high temperatures and is self-priming. Features include use of stainless-steel shaft, hydraulically balanced rotor, large bearings and renewable heads. Manufacturer: Walter H. Eagan Co., 2336 Fairmount Ave., Philadelphia 30.

For additional information circle MD 15 on page 253

High-Pressure Snap-Action Switch



Particularly applicable for the control of high-pressure hydraulic systems, the Hydtrol switch has linear adjustment over an operating range from 50 to 5000 psi. Rated 10 amperes at 110 volts a-c or 2 amperes at 28 volts d-c, the switch is of snap-action type and has on-off differential adjustment ranging from 5 to 50 per cent. Unit is enclosed with an explosion-re-

sistant housing and is protected against corrosion and moisture. Especially useful in applications where space is limited, the switch occupies 9½ cubic inches and weighs 17 ounces. Manufacturer: Diaphlex division, Cook Electric Co., 2700 Southport Ave., Chicago 14.

For additional information circle MD 16 on page 253

One-Horsepower A-C Motor

Sturdy one-horsepower motor is designed to operate on either 115 or 230-volt excitation in either clockwise or counterclockwise direction. The new unit has a starting torque three times as great as full-load torque and will handle momentary overloads equal to twice full-load torque. Cool operation is obtained by fan ventilation. Features include: Drip proofing, grease-proof protective armor and shaft-opening covers. Motor is available in either single or polyphase types. Manufacturer: Eicor, Inc., 1501 W. Congress St., Chicago 7.

For additional information circle MD 17 on page 253

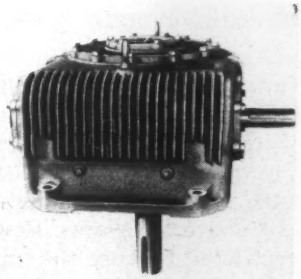
High-Pressure Hydraulic Pump

Compact single-stage hydraulic vane pump is rated at 2000 psi and will operate at 1800 rpm. Hydraulically balanced for pressure and flow, no hydraulic loads are imposed on the bearings of the Dudco pump. Patented feature keeps the vanes tight against the ring regardless of pressure. Pump is available in two series: P-2 for pressures up to 2000 psi and capacities to 32 gpm; and P-80 for pressures of 750 to 1500 psi, and capacities to 80 gpm. Manufacturer: Dudco Products Co., 18100 Ryan Road, Detroit 12.

For additional information circle MD 18 on page 253

Right-Angle Speed Reducers

Line of 7-inch center-distance speed reducers is made in 10 standard ratios ranging from 5:1 to 70:1. New series, known as 7700, is available in 3 types: HU-7700, with pinion under gear; HO-7700, with pinion over gear; and HV-7700 with gear shaft vertical. All ratios and types are also made with double-extended gear shafts or double extended pinion shafts. Mechanical ratings of the reducers are 1.56 hp at 100 rpm for the 70:1 ratio, to 94.2 hp at 2400 rpm for the 5:1 ratio. Outside dimensions of the HU-7700 and HO-7700 housings are 18⅞ by 15⅛ by 25⅝ inches. On the HV-7700 housings dimensions are 23⅝ by 17 5/16 by 15⅜ inches. Manufacturer: Cone-Drive division, Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12.



For additional information circle MD 19 on page 253

High-Strength V-Belt

Possessing features particularly applicable to tough drives, Ray-Man V-belt has been especially designed for heavy service. Added features of the belt are heat, oil and static resistance. Manufacturer: Manhattan Rubber Div., Raybestos-Manhattan Inc., Passaic, N. J.

For additional information circle MD 20 on page 253

Electronic Servo System

Automatic electronic remote-control and positioning unit for the control of all types of mechanical systems consists of three basic units. These are, the transmitter, the control amplifier, and receiver. While designed to operate with high accuracy, the system is constructed for heavy use and has strong dust-proof case built to withstand shock, vibration and corrosion. Models are available with output torques of 50, 100 and 220 lb-in. All three models permit 90 degrees of rotation. Manufacturer: Askania Regulator Co., 240 E. Ontario St., Chicago 11.

For additional information circle MD 21 on page 253

Phenolic Resins and Varnishes

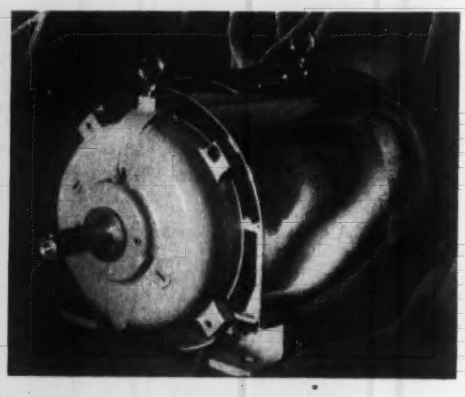
Varnishes and thermosetting resins with a phenolic base are suitable for a wide variety of laminating, impregnating and insulation applications. The resins are made in four grades. Grade 12300 has high mechanical strength and is soluble in water. It was developed for the impregnation of paper. Grade 12302 is suitable for production of odorless laminates, such as used near food. Both 12303 and 12304 are recommended for use where high surface hardness and mechanical strength are required. The varnishes, made in two types, are suitable for applications where high mechanical strength and good electrical properties are required. Grade 12301 is a general

purpose varnish used for high pressure laminating, etc., grade 12305 can be used for either high-pressure or low-pressure fabrication. Manufacturer: Chemical department, General Electric Co., Pittsfield, Mass.

For additional information circle MD 22 on page 253

Corrosion-Resisting Motor

Meeting Underwriters Laboratories standards for operation under class-I, group D conditions, this motor is of corrosion-resisting construction. Outer cover and cable outlet are Monel metal; fan is bronze and



conduit box is cast-iron. Frame sizes available are numbers 203 to 326, inclusive. Manufacturer: Reliance Electric & Engineering Co., 1079 Ivanhoe Road. Cleveland 10.

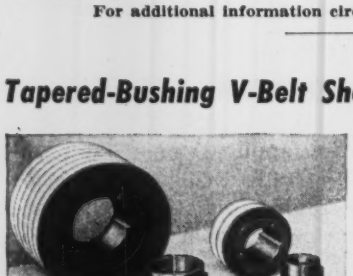
For additional information circle MD 23 on page 253

Standard Chain Drives

Now available in ½ and ¾-inch pitches, line of industrial-standard stock silent chain is made with middle guide. Widths of ¾, 1, 1½, 2, 3 and 3½ inches are covered by the smaller pitch and 2, 3, 4 and 5-inch widths are accommodated by the ¾-inch pitch chain. Features of the new chain include the use of Taper-Lock bushings for easy assembly and all steel pinions with hardened teeth for long life. Manufacturer: Link-Belt Co., 307 N. Michigan Ave., Chicago 1.

For additional information circle MD 24 on page 253

Tapered-Bushing V-Belt Sheaves



Made in a wide variety of styles to suit many sizes of V-belts, Gripbelt sheaves are now available with split taper bushings. The sheave grips the drive shaft with a positive clamping fit which will withstand vibrations and heavy loads without loosening. A built-in key guides bushing in assembly and provides positive drive. Since bushing barrel is split, the tightening of the locking capscrews forces bushing into tapered bore of the sheave. Sheave is removed from shaft by inserting screws in bushing flange holes. Unseating action releases bushing from sheave so that entire assembly will slide from shaft. Manufacturer: Browning Mfg. Co., Maysville, Ky.

For additional information circle MD 25 on page 253

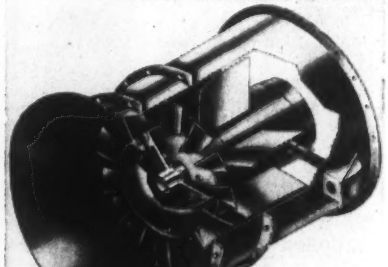
Large-Size Plastic Sheets

Acrylic sheets measuring up to 100 by 120 inches, in thicknesses from ¼ to ½-inch are now being made. Twice the size of previous plastic sheets made by this manufacturer, the material makes possible numerous nonsegmented designs not heretofore possible. Manufacturer: Rohm & Haas Co., Washington Square, Philadelphia, Pa.

For additional information circle MD 26 on page 253

Adjustable-Blade Fans

Feature of the series 1000 Axivane fans is their adjustable blades, insuring performance flexibility. The fans are simple and compact in design with direct in-line drive which lowers installation costs, minimizes space requirements and develops maximum volume. Models available are designed for pressures ranging up to 9.60 inches of water, and volumes up to 100,000



cfm. The 124 different models provide numerous combinations of housing diameters from 18 to 60 inches, 4 hub sizes, 16 motor frame sizes and 4 different speeds. Manufacturer: Joy Mfg. Co., Oliver Bldg., Pittsburgh 22.

For additional information circle MD 27 on page 253

Hydro-Pneumatic Flow-Control Valve

Assuring high efficiency and full use of fluid power, flow-control valve eliminates abnormal pressure of the exhaust from the return side of the cylinder, increasing cylinder effective pressure. When flow is toward the cylinder, a ball check closes and the flow path is directed through the flow-control portion of the valve. Reverse flow from the cylinder is unrestricted because the unloaded ball check opens wide on a slight change of pressure. Compact, the valve

THE BEARINGS THAT *Fit like a Glove*

Johnson Bronze Sleeve Bearings Give You Every Worthwhile Advantage

- LOW COST
- PRECISION
- QUIET
- LONG LIFE
- CORROSION RESISTANT
- UNIT CONSTRUCTION
- LOAD CARRYING CAPACITY
- HIGH RESISTANCE TO SHOCK
- LOW COEFFICIENT OF FRICTION
- EASY TO INSTALL
- CONFORMABILITY
- NATION WIDE SERVICE

Slip your hand into a glove and note how quickly and easily it assumes the shape and contours of the fingers. This illustrates CONFORMABILITY . . . a valuable, cost saving feature of Sleeve Type Bearings.

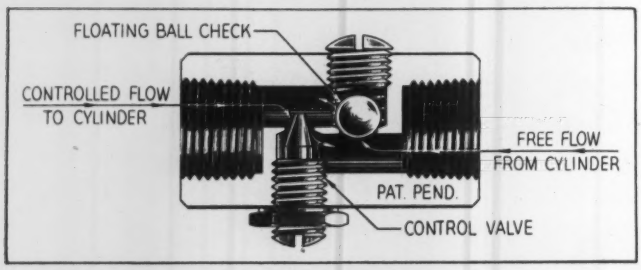
When you place a Sleeve Bearing into a housing or over a shaft you need not worry about slight misalignment or minor irregularities of the other parts. Its plastic quality enables the bearing to conform quickly to the surroundings. This provides a smooth, unbroken surface . . . to carry the loads . . . to reduce friction to the minimum. This feature saves considerable time and money in assembly . . . assures long, trouble-free service.

Conformability is but one of many outstanding characteristics of Johnson Sleeve Bearings . . . each of which means lower costs to manufacturers of equipment . . . longer bearing life to the user. Why not tell us about your bearing needs now? Let us help you get greater service at lower costs . . . without obligation.

JOHNSON BRONZE COMPANY
525 SOUTH MILL ST. NEW CASTLE, PA.

JOHNSON BRONZE
SLEEVE BEARING HEADQUARTERS

BRANCHES IN 20 INDUSTRIAL CENTERS



is only slightly larger than the pipe to which it is fitted. Three sizes are made: ¼, ⅜ and ½-inch pipe sizes. Body is brass hexagonal bar stock. All other parts are stainless steel. Manufacturer: Pneu-Trol Devices Inc., 3122 N. California Ave., Chicago 18.

For additional information circle MD 28 on page 253

D-C Auxiliary Motors

Line of railway auxiliary motors are designed for driving blowers, battery-charging generators and air compressors on vehicles operating on 600-volt d-c systems. Available in sizes from 1 to 4 hp, the motors have full-load speeds ranging from 1150 to 1935 rpm. Special features are said to make the motors resistant to damage from road shock and severe vibration encountered in the transportation field. Manufacturer: General Electric Co., Schenectady, N. Y.

For additional information circle MD 29 on page 253

Silent-Chain Drives

Series of silent-chain standard drives having Taperlock bushings is designed to reduce the number of basic components and simplify specification. Already available in ½ and ¾-inch pitch chain sizes, the drives are to be made in a wide range of sizes using bushings having bore diameters in increments of 1/16-inch. Other features include the use of a single center guide link and the ability of the six dual-duty sprocket face widths to operate with eleven stock chain widths. Manufacturer: Morse Chain Co., 7601 Central Ave., Detroit 8.

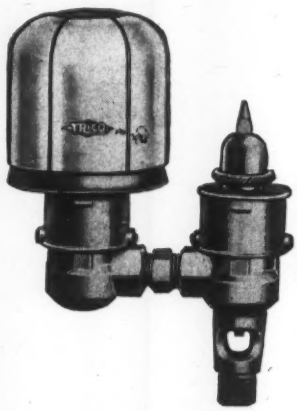
For additional information circle MD 30 on page 253

Plastic Refrigerator Sealant

Resilient, moistureproof and vaporproof sealant has been developed for use in keeping moisture-laden air from the insulation space in refrigeration equipment. New material, known as Sub-Zero sealer, may be used in all-steel or steel and wood construction. In either case it is applied along the joints. The sealant has a melting point of 240-260 F, and will not flow when equipment is shipped or stored during high summer temperature. It is said not to crack at temperatures as low as −25 F. Manufacturer: Armstrong Cork Co., Lancaster, Pa.

For additional information circle MD 31 on page 253

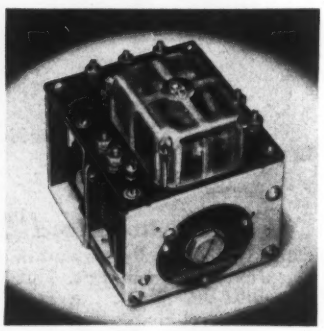
Gravity-Feed Oiler With Filter



Made in 1, 2, 4 and 8-ounce capacities, gravity-feed oiler features built-in filter which prevents dirt from clogging needle valve or reaching bearing. Oiler is mounted at the top of the unit to be lubricated and any predetermined number of drops of oil can be obtained by adjustment of the needle valve. A shutoff lever is provided. When in vertical position, it feeds oil. When tilted to the side it stops flow, and when held at a 45-degree angle it flushes the bearing. Bottle is clear shatterproof plastic, removable for easy filling. All metal parts are heavily plated. Manufacturer: Trico Fuse Co., 2948 N. 5th St., Milwaukee.

For additional information circle MD 32 on page 253

Motor-Driven Time-Delay Relay

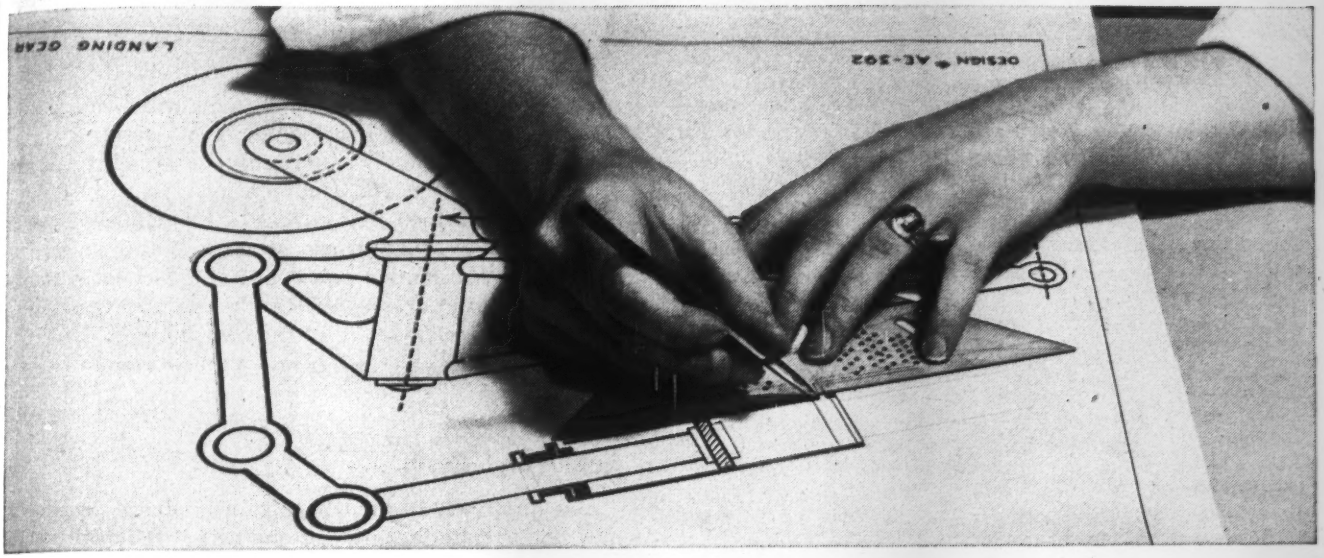


Motor - driven time-delay relay having composite connections is designed for use with systems where an adjustable time delay is required for automatic or sequential operation. By the connection of external jumpers, two different timing sequences can be obtained, delayed make or instantaneous make and delayed break. Unit consists of a synchronous motor, differential gear system, brake assembly, trip-switch assembly and auxiliary relay. It is also equipped with safety locking device, preventing any unintentional change in time setting. Having a timing range to 63 minutes, unit features immediate self-recycling, vibration-resistance construction and quick make and break load circuits. Manufacturer: Ward Leonard Electric Co., Mount Vernon, N. Y.

For additional information circle MD 33 on page 253

Sanitary Swivel Joint

Providing full 360-degree rotation in one or two planes, new stainless-steel swivel joints are designed to meet sanitary requirements in the food processing



NEW OZACLOTH...

improves even your best drawing!

Order an Ozacloth print of your best pencil or ink drawing... and you'll be the first to admit the improvement.

For Ozacloth has characteristics never present in an original drawing... never offered before in an "Intermediate" print:

1. OZACLOTH increases the opacity of pencil and ink images...gives you a translucent "duplicate" which produces better prints than the original.

2. OZACLOTH retains this improved line detail through the years. You have permanent sepia images—no pencil lines to smudge. No ink lines to run. No "surface" images to chip. No loss of opacity or reduction in reprint speed.

3. OZACLOTH resists wear and tear...has a superior tracing cloth base...that's plastic coated...impervious to water, grease, grime. Besides, Ozacloth can be cleaned with a damp cloth in seconds... and its images will not "offset" onto other prints in your files.

4. OZACLOTH speeds up print production... is processed in usual manner in your Ozalid machine... turns out subsequent prints in 26 seconds or less.

5. OZACLOTH "corrects" in seconds. Deletions can be made with corrector fluid, or sand eraser—easily, precisely. Additions can be made in pencil or ink on either side of matte surface.

6. OZACLOTH cuts costs! For example, you can make a permanent 8½ x 11 print for 26 cents; a 17 x 22 print for 52 cents. *A fraction of the cost of your original drawing... yet full insurance for years to come!*

Mail coupon today for *free* Ozacloth sample.

DEPT. NO. 79

OZALID, A Division of General Aniline & Film Corporation, Johnson City, New York

Gentlemen:

☐ Please send free sample of new Ozacloth.

☐ Please send complete information on Ozalid process.

No obligation.

Name_____ Position_____

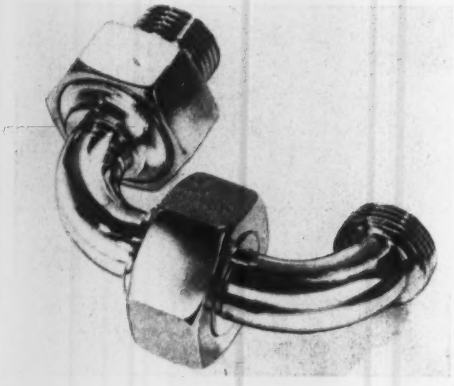
Company_____

Address_____

Ozalid in Canada—Hughes Owens Co., Ltd., Montreal

See ★ Feel ★ Try new Ozacloth

industry. Threads and elbows are made to specifications and diameters required by the Dairy Industry Committee code on sanitary fittings. Fusion welding of parts provides a smooth nonporous surface. A packing ring is of synthetic material bonded to an inner ring of stainless steel, this mates with a seat which is hard-chrome plated, providing smooth turning and long life. The joints have a pressure capacity of 100 psi and will operate under vacuum as well as pressure. Sizes available are 1, 1½ and 2 inches in six different styles. Manufacturer: Chicksan Co., Brea, Calif.



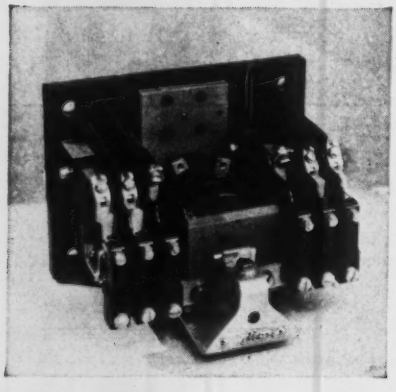
For additional information circle MD 34 on page 253

Steel Balls

Precision steel balls in 22 sizes are now available in small lots. Packaged in individual containers, lot quantities vary from 350 for the 3/32-inch diameter balls to 4 for the 1-inch balls. Manufacturer: Atlas Ball Div., SKF Industries, Inc., Front St. and Erie Ave., Philadelphia.

For additional information circle MD 35 on page 253

Heavy-Duty Multipole D-C Relay



Rear - connected, multipole d-c relay designated the AYB is made in 4, 6, 8, 10 or 14-pole combinations. The relay is designed for operation at 600 volts and below and has a maximum interrupting capacity of 150 volt-amperes. Its salient feature is a fast drop-out of the contacts when the coil is de-energized. The relay may be had with contacts that operate all normally-open or in combination with some contacts normally-open and some normally-closed. To prevent overloading the operating magnet, not more than five normally-closed contacts are ordinarily used in the combination. The AYB unit is a self-contained relay with all component parts mounted on ½-inch thick Micarta plate, it can be mounted on a control panel up to 2 inches in thickness. Manufacturer: Westinghouse Electric Corp., 306 4th Ave., Box 1017, Pittsburgh 30.

For additional information circle MD 36 on page 253

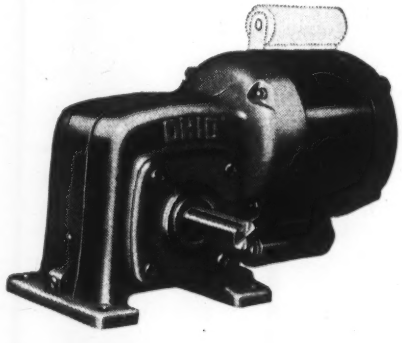
New Vinyl Resin

Marvinol VR-10, a vinyl thermoplastic resin, is now being manufactured in quantity. It is said to be the first high molecular weight vinyl resin which can be extruded or made into rigid forms. Manufacturer: Glenn L. Martin Co., Baltimore 3.

For additional information circle MD 37 on page 253

Motorized Speed Reducers

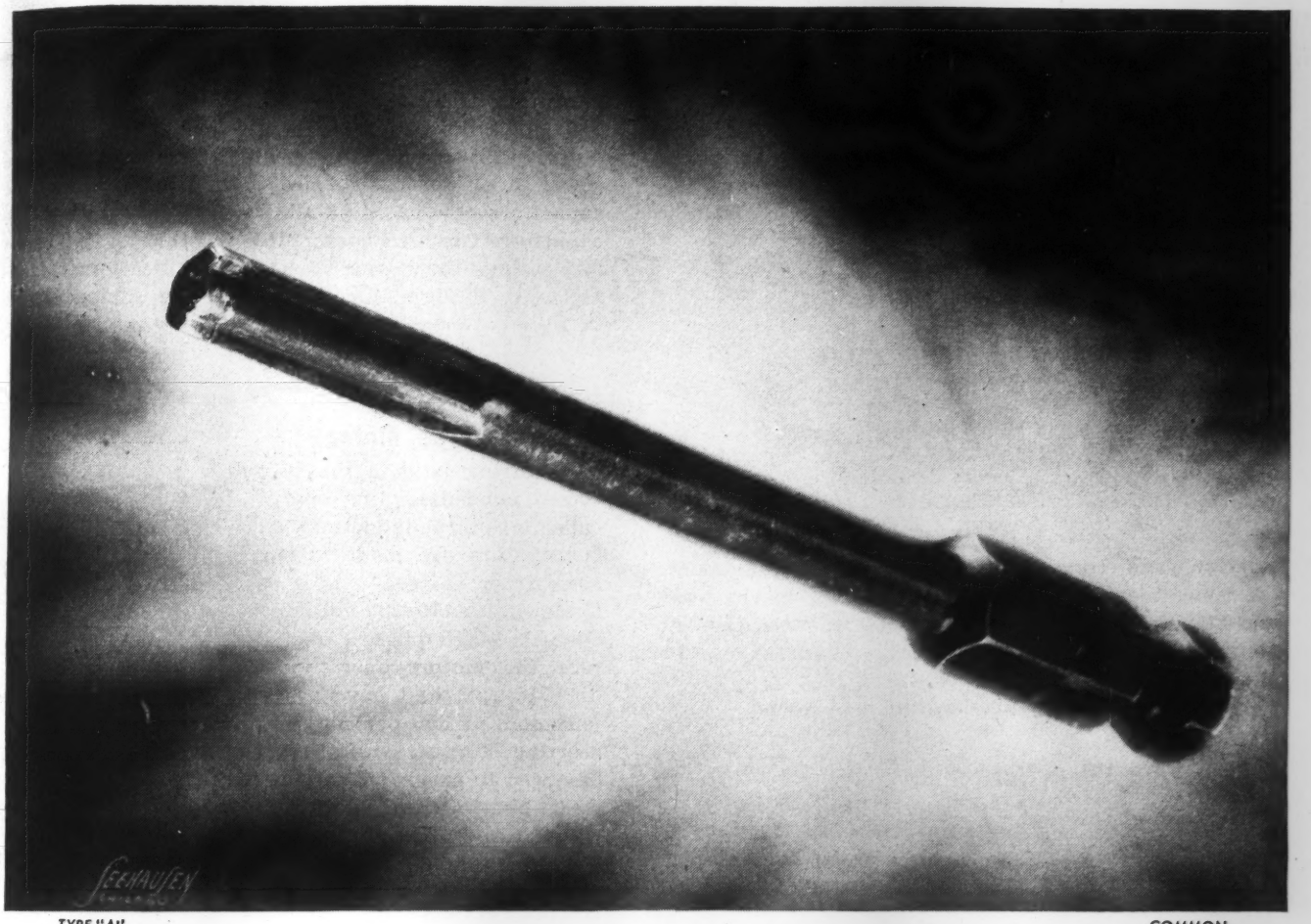
Line of speed reducers for outputs from 24 to 317 rpm have reduction ratios from 5:1 to 72:1. Designated series M-1300 and M-1400 for 1/3 and ¼-hp transmission, respectively, the reducers are available with either capacitor or three-phase motors. The capacitor motors are suitable for 115 and 230-volt operation while the polyphase motors are used with 220 and 440 volt power. Reducers are attractive in design having housings of aluminum alloy. Worm gears are gear bronze; worm and motor shaft are integral and are hardened steel, ball-bearing mounted. Special feature is the Torq Syncrosnap starting switch which insures precise snap action and eliminates damage through burned-out windings. Manufacturer: Ohio Gear Co., 1338 E. 179th St., Cleveland.



For additional information circle MD 38 on page 253

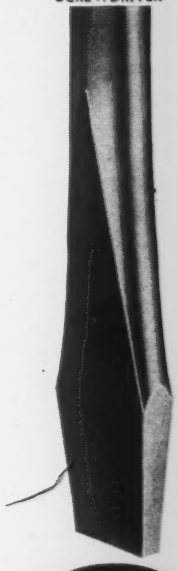
Manual-Reset Thermal Timer

Actuated by a heater element wound on a bimetallic strip, new timer has a range of 20 seconds to 3 minutes. Unit can be set for any desired time delay



TYPE "A" ASSEMBLY BIT

COMMON SCREWDRIVER



This Bit DROVE 214,000 SCREWS

IN CONTINUOUS OPERATION

This amazing record of durability was rolled up on an assembly line of the largest automobile corporation in the world.

It is a stock bit, taken out of production shipment and was used in a power driver on $\frac{5}{16}$"-24x$\frac{7}{8}$" flat CLUTCH HEAD door hinge screws . . . an operation calling for unusually high torque driving.

It is important to note that this bit served continuously on the assembly line . . . *that there was no interruption for reconditioning* during this 214,000 driving spell.

Moreover, this bit can be *repeatedly restored to its original efficiency* by a simple application of the end surface to a grinding wheel.

Package assortment of CLUTCH HEAD Screws and sample Type "A" Bit sent on request

Tool economy is only one of the many exclusive advantages offered by CLUTCH HEAD *for faster, safer, and lower-cost assembly operation. Investigate them.*

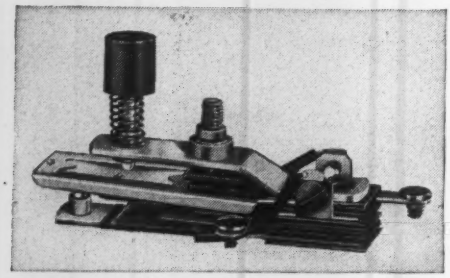
CLUTCH HEAD SCREWS

Check the perfect operation of this screw with an ordinary type screwdriver or any flat blade, reasonably accurate in width. Thickness of the blade is secondary.

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

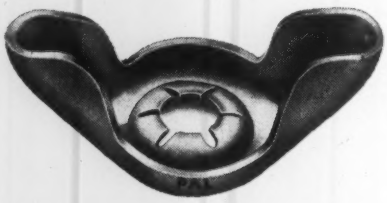
in its range before breaking contact. When circuit is broken, pushbutton must be pressed to reset. Standard model has normally-closed heavy-duty contacts. Other features include use of mica and ceramic in-



sulation, and corrosion-resistant metals. Compact, the timer measures 3½ inches long, 1¼ inches wide and 1⅛ inches high. Rating is 1500 watts at 115-230 volts ac. Manufacturer: George Ulanet Co., 414 Market St., Newark 5, N. J.

For additional information circle MD 39 on page 253

Self-Locking Wing Nut



Employing the same type of thread used in other Palnuts, new wing nut provides vibration-proof qualities in a low-price wing nut. Proportions of the wing structure have been designed to provide a comfortable finger grip, yet not be bulky in size. The No. 10-24 in now available from stock; ¼-20 nuts will soon be in production. Manufacturer: Palnut Co., 75 Cordier St., Irvington, New Jersey.

For additional information circle MD 40 on page 253

Tough Thermoplastic

Lightweight, easily formed thermoplastic known as Versalite has high impact strength, low water absorption and excellent insulating properties. It can be formed into irregular and compound shapes as large as 5 by 5 feet and made in any thickness above 0.020-inch. The material can have solid color throughout with dull, satin, gloss or embossed finish. It will not chip or warp and is highly resistant to gasoline, oils and most commercial cleaners. Manufacturer: United States Rubber Co., Rockefeller Center, New York.

For additional information circle MD 41 on page 253

High-Voltage Capacitors

Rated 8000 to 20,000 volts dc, and designed for operation at temperatures up to 85 C, Vitamin Q d-c capacitors require no derating up to this temperature. They are also available for service up to 115 C. Units are hermetically sealed and provided with solder-sealed glass terminal bushings; they are equal to or smaller in size than prior types of d-c capacitors now in use. Made in 19 standard sizes, the capacitors can also be supplied in other shapes, sizes and ratings for a wide variety of applications. Manufacturer: Sprague Electric Co., North Adams, Mass.

For additional information circle MD 42 on page 253

Capacitor-Type Motor

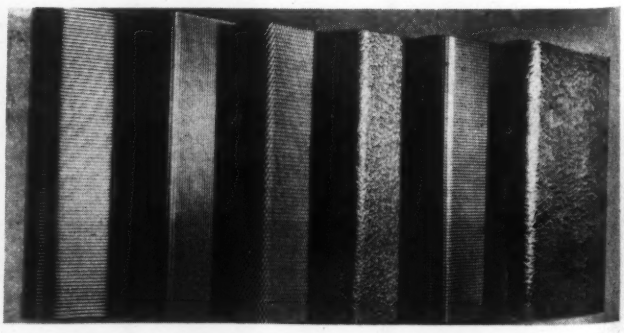
Featuring built-in fan-cooled condenser, line of capacitor-start induction run motors are made in sizes from ¼ to 1½ hp. Designed for 115/230-volt, 60-cycle, single-phase current the motors operate at 1725 rpm and have a minimum of 350 per cent starting torque. Rotating parts are dynamically balanced to assure vibration-free performance. Sturdy steel housing and slotted, welded steel base give rigidity and true alignment. Recommended applications include air-conditioning equipment, fans, and stokers. Manufacturer: Brown-Brockmeyer Co., P. O. Box 976, Dayton 1.

For additional information circle MD 43 on page 253

Embossed Aluminum Sheet

Raised patterns are embossed on the surface of newly available aluminum sheet, affording an attractive appearance and eliminating the need for finishing operations. The decorative surface hides wear, giving parts a long service life. Increased rigidity allows thinner sections to be used than heretofore possible. Material is made in flat sheet in thicknesses ranging from 0.010 to 0.040-inch and in widths from 12 to 48 inches. It is also made in coils in the same thicknesses and in widths ranging from 6 to 36 inches. Wide number of patterns are available to suit specific needs. Manufacturer: Reynolds Metals Co., 2500 S. 3d St., Louisville, Kentucky.

For additional information circle MD 44 on page 253



The Biggest News in 60 Years of Aluminum Castings

Today's metal prices make aluminum castings competitive with heavy metal castings! You can now design all the advantages of Alcoa Aluminum into your product, and actually save money in many cases!

What's more . . . you won't have to stand in line to get aluminum castings. Alcoa's 8 foundries and 2 die-casting plants will give you fast quotations from your blueprints, will give you prompt delivery of aluminum castings in quantities to let you run your assembly lines at maximum efficiency.

Clean castings . . . Alcoa Aluminum Castings reach you clean and smooth, cast to accurate dimensions and contours. They're ready for you to finish-machine without costly hand-filing and sawing. They stay bright without painting, can never redden from rust.

Light weight . . . Alcoa Aluminum Castings weigh only 40% as much as iron castings. You can beef-up stressed sections if necessary, and still save half on weight. Cost less to handle—all through production.

Ask Alcoa for technical data and engineering help in using aluminum castings in your products. Telephone the nearby Alcoa sales office, or write to ALUMINUM COMPANY OF AMERICA, 1940 Gulf Building, Pittsburgh 19, Pennsylvania. Sales offices in 54 leading cities.

Aluminum Castings by ALCOA

ALCOA ALUMINUM

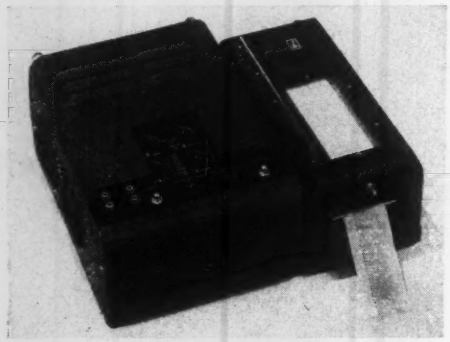
SAND • DIE PERMANENT • MOLD •

engineering dept equipment

In order to obtain additional information on this new equipment see Page 253

Direct-Recording Strain Gage

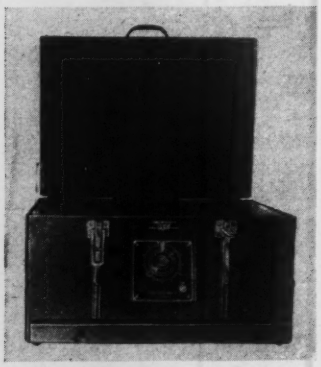
Designed for use with the Brush direct-inking oscillograph, the BL-310 amplifier consists of three direct-coupled stages, matching the characteristics of the oscillograph. It can, however, be used with any resistance-sensitive pickup. The amplifier contains two legs of a Wheatstone bridge network. The third and



fourth legs are connected externally by the user, one leg being the active gage and the other being used for sensitivity doubling or temperature compensation. Provision is made for connecting an internal calibrating resistor in the circuit and for adjusting the overall gain. Manufacturer: The Brush Development Co., 3405 Perkins Ave., Cleveland 14.

For additional information circle MD 45 on page 253

Photographic Copying Machine



Equipped with an automatically-set electric timer, the Tru-Copy - Phote machine can be used to photographically reproduce material to 14 by 20 inches. Built of reinforced plywood and covered with washable rubberoid cloth, the copying unit is furnished complete with all developing accessories. It operates on 115-volt alternating current and can be used in ordinary office light without the use of darkroom or heating unit. Manufacturer: General Photo Products Co., General Photo Building, 15 Summit Ave., Chatham, N. J.

For additional information circle MD 46 on page 253

Paper Cutter

Made in five different sizes, the Touch-O-Matic paper cutter consists of two main sections: An upper part or cutting board and a bottom section or base. A fixed cutting blade is attached to one end of the cutting board, and the other end of the board is hinged to the base to allow up and down motion. The base piece holds one or two cutting blades at the cutting end. In operation, paper is placed on the cutting board and slipped under the cutting blade to the desired position. When board is pressed, paper is cut. Springs return the board to normal position. Blade arrangement is such that the cutter is almost self sharpening, thus eliminating frequent maintenance. Standard models have cutting widths of 18, 24, 30, 36, and 42 inches with added clearance of 2 inches over designated size. Three larger models are available with either single or double foot pedals. Manufacturer: Hobbs Mfg. Co., 26 Salisbury St., Worcester, Mass.

For additional information circle MD 47 on page 253

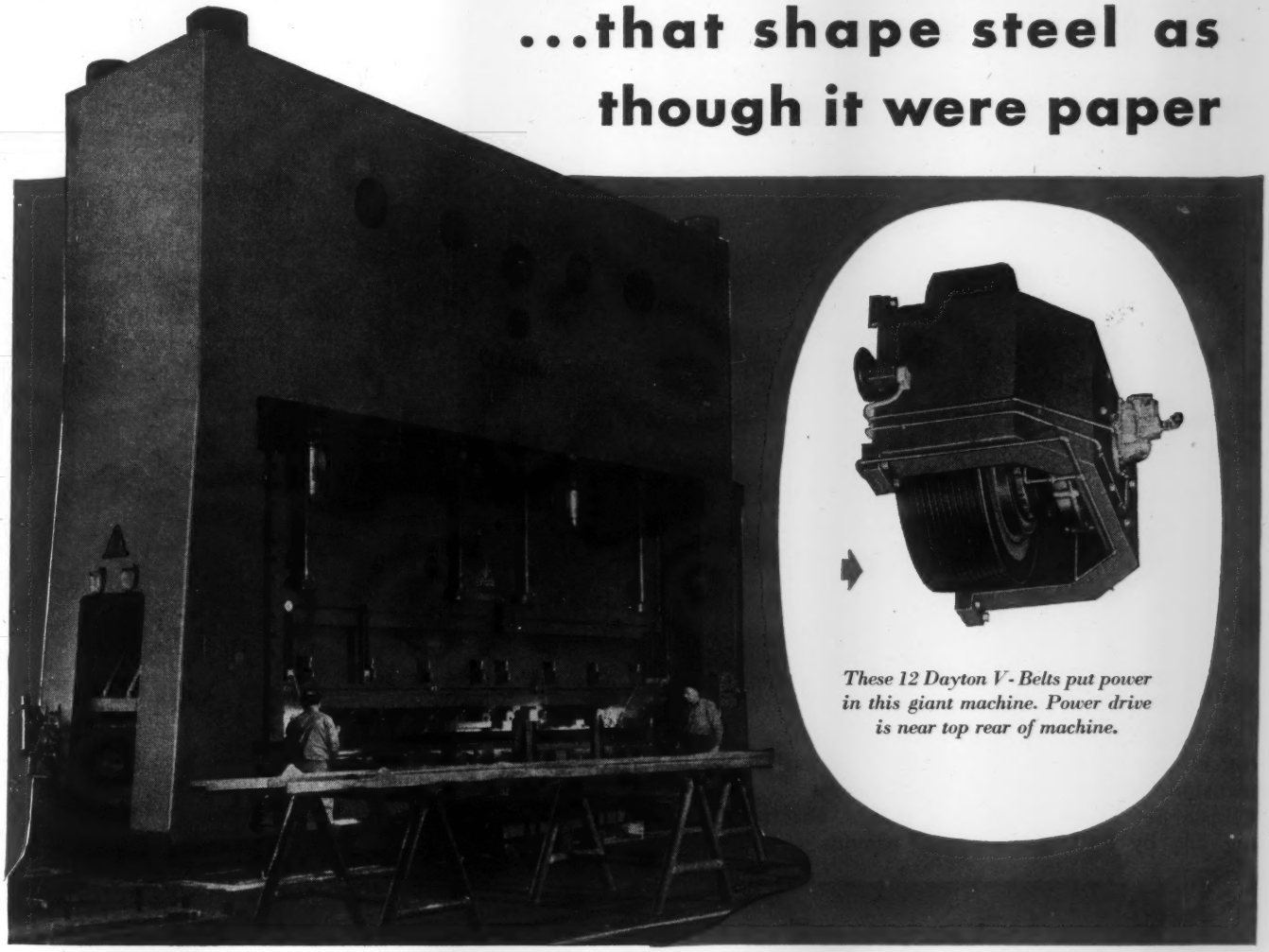
Dry-Process Reproduction Unit

Ammonia-type, dry-process drawing reproduction unit quickly makes a variety of positives, negatives, etc., direct from the original. The machine develops continuous prints up to 42 inches wide from cut

sheets or roll stock at a speed of 5 feet per minute, operating on 110-volt, 60-cycle current. It occupies a space of 20 inches deep and 70 inches wide. Complete combination unit includes a continuous printer,

3,000 ton muscles

...that shape steel as though it were paper



These 12 Dayton V-Belts put power in this giant machine. Power drive is near top rear of machine.

● The man-made monster pictured above is the largest mechanical press ever built for automotive parts manufacture. You feed it steel blanks, push buttons, and in one quick stroke 3,000-ton muscles shape the steel into 33-foot-long side rails for the frames of the largest busses, trucks and trailers. Forty-two and a half feet high, this mighty Clearing Machine Corporation press weighs 500 tons!

Naturally, the V-Belt Drive that actuates the press' power drive mechanism is subjected to severe operating conditions. Because Dayton V-Belts are built to absorb the stresses and strains of sudden stops and starts, uneven loads and shock loads, they were chosen for the drive. Scientifically designed, Dayton V-Belts flex easily around pulleys without heating, yet provide maximum cross-sectional rigidity. Built with the super strength of Raytex Fortified Cords, they give top service under the most grueling conditions.

The ability of Dayton V-Belt Drives to operate in excess of standard requirements under all operating conditions . . . unaffected by oil, heat, dust or liquids . . . is one of many reasons why more and more industrial designers consistently specify Dayton V-Belts for original equipment. A Dayton power transmission specialist is ready to help you. For additional information write *The Dayton Rubber Company, Dayton, Ohio.*

INDUSTRIAL DESIGNERS!

All standard Dayton V-Belts have the extra strength of Raytex Fortified Cords . . . Dayton's specially processed Rayon cords that make possible *minimum stretch, maximum strength* and *longer life*. For the complete story, write today for Booklet A-469.

Dayton Rubber

THE MARK OF TECHNICAL EXCELLENCE IN NATURAL AND SYNTHETIC RUBBER

an ammonia-fume developer and a combination floor stand. It is finished in baked olive-green wrinkle lacquer. Manufacturer: Peck and Harvey, 5736 N. Western Ave., Chicago 45.

For additional information circle MD 48 on page 253

Electric Erasing Machine

Balanced to fit the hand, Handee electric eraser weighs 12 ounces and will utilize any of the standard erasers, permitting sharp, clean erasing. All moving parts of the machine, with the exception of eraser, are completely covered by protective shield, fully protecting the fingers. Optional equipment includes a convenient foot control permitting full freedom of the hands in using the eraser and absolute control by the foot switch. Manufacturer: Chicago Wheel & Mfg. Co., 1101 W. Monroe St., Chicago 7.

For additional information circle MD 49 on page 253

Drafting-Template Set

Set of four drawing templates may be used in forming ellipses from 3/8 to 2¾ inches in major-axis dimension. The set, which is known as the No. 401 Ellipse Set Folio, consists of plastic sheets measuring 4¾ by 9¾ inches. They provide a projection-

angle range of 20, 30, 45 and 60 degrees with sizes and center lines indicated. Reinforced folio serves to store and protect the templates. Manufacturer: Rapidesign, Inc., P. O. Box 592, Glendale, Calif.

For additional information circle MD 50 on page 253

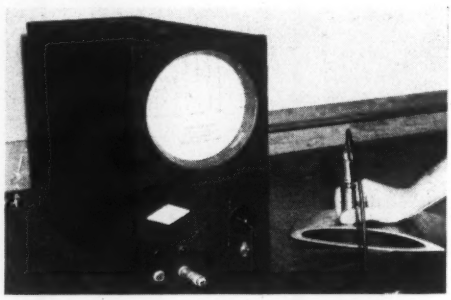
Fluid-Flow Calculator

Called the "Tube-Turn velocity and pressure drop calculator," new slide rule gives two kinds of answers to fluid flow problems. It gives a quick estimate of values based on a pipe friction factor of 0.006 and an accurate solution derived from the estimate by applying a correction factor to the straight pipe losses. One part of the rule is devoted to liquids and another to gases. The friction factor correction chart and the slide give fitting and valve losses. Owing to compressibility effect, the calculator will not give accurate solution for gases where the pressure drop exceeds 15 per cent or the initial pressure. Manufacturer: Tube Turns Inc., 224 E. Broadway, Louisville 1.

For additional information circle MD 51 on page 253

Thickness-Measuring Instrument

Utilizing supersonics, this new instrument will measure thickness within 2 per cent as well as detect flaws. All measuring can be done from one side of the material or part, thus wall thickness of hollow objects can be determined accurately. Readings of



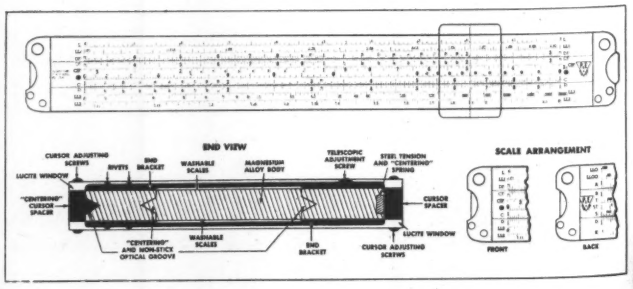
thicknesses between 0.005-inch and 0.300-inch can be made directly from the instrument screen while indirect reading of dimensions up to 4 inches can be made with a slight calculation. Manufacturer: Sperry Products, Inc., 15th St. & Willow Ave., Hoboken, N. J.

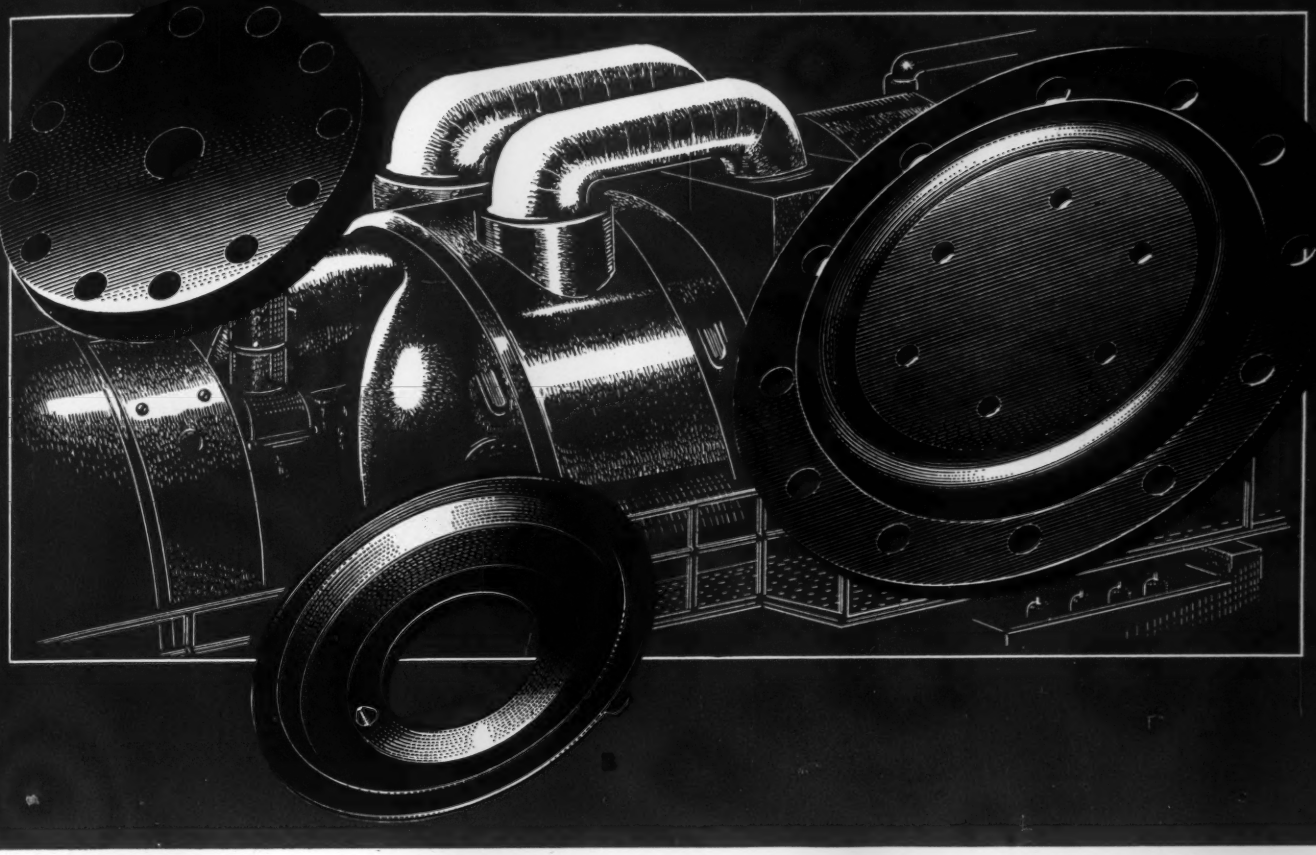
For additional information circle MD 52 on page 253

Log-Log Slide Rule

Precision-made, ortho-phase log-log slide rule is of metal construction to reduce warping. The instrument is manufactured to an 0.001-inch tolerance. A cursor groove and spring channel keep cursor centered and away from the scale surface; adjusting screws afford easy line-up of scale and the entire scale is unaffected by repeated cleaning. The instrument has standard log-log scales and measures 12⅛ by 1½ by ⅛-inch. Manufacturer: Pickett & Eckel Inc., 1111 S. Fremont Ave., Alhambra, Calif.

For additional information circle MD 53 on page 253





HOW SIRVENE SERVES IN *Heavy Equipment*

"A" is a diaphragm used in the feed water pump on a high-powered boiler. "B" is a vacuum activated diaphragm which boosts the hydraulic brakes on automobiles, trucks, and semi-trailers. Diaphragm "C" opens and shuts the large globe valves used in industrial and municipal water purifying plants.

The contrast between these heavy-duty pliables and the tiny featherweight Sirvene parts used in other mechanisms provides a dramatic demonstration of Sirvene's broad range of application. Each Sirvene part is different in every way—in design and in basic structure. Each is specially engineered and developed to serve under unusual and difficult operating conditions—where consideration may have to be made for extremes of temperature or pressure, flexibility, resistance to oils, chemicals, water or other solvents, and wear or erosive action.

You'll find Sirvene serving wherever engineers have needed special pliables to solve their problems. Sirvene can serve you, too.

At your service—Sirvene engineers' vast experience and resources, for the solution of your most intricate pliable parts problems.

CHICAGO RAWHIDE MANUFACTURING CO.

1304 Elston Avenue SIRVENE DIVISION Chicago 22, Illinois

Sirvene products include diaphragms, boots, gaskets, oil seals, washers, packings, and other special molded mechanical pliables

OTHER C/R PRODUCTS
PERFECT Oil Seals
SIRVIS Mechanical Leather

ENGINEERS: For basic information, write for your copy of "Engineering with Sirvene." There is no charge.

SIRVENE

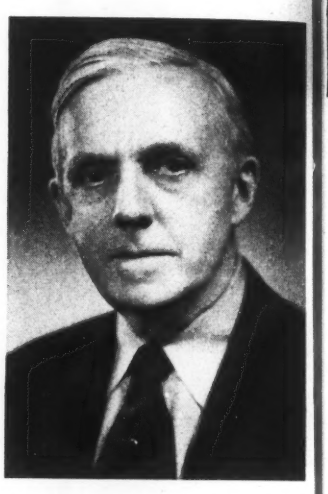
THE *SCIENTIFIC* COMPOUNDED ELASTOMER

OUR 70th YEAR OF INDUSTRIAL SERVICE

MEN...of...machines

R. C. Osborn

Dr. J. T. Rettaliata

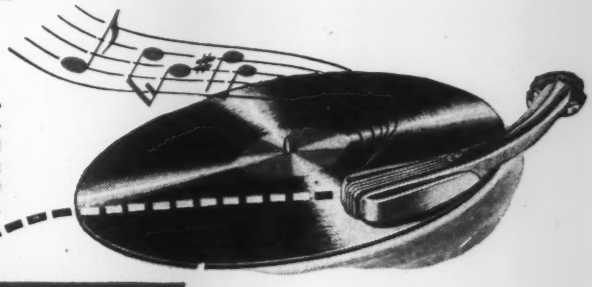


Stanwood W. Sparrow

R. C. OSBORN, formerly chief engineer of the Eureka Div., Eureka Williams Corp., Bloomington, Ill., has been named director of engineering for the entire corporation. Following studies in mechanical engineering at Ohio Northern University, Mr. Osborn joined Western Electric Co. in 1930 as an installation engineer, later becoming a designer for Valves & Presses, Inc. and a staff engineer for the Hoover Co. Immediately prior to the war, Mr. Osborn was director of engineering for the Tobe Deutschman Corp., and during the war was associated with the Applied Physics Laboratory of Johns Hopkins University on production engineering phases of the proximity fuse project. Mr. Osborn has been associated with Eureka Williams since September, 1945.

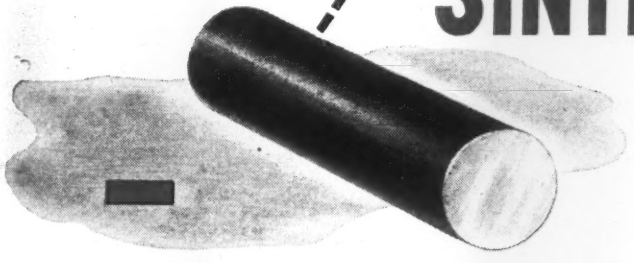
DR. JOHN T. RETTALIATA, director of the department of mechanical engineering, Illinois Institute of Technology, has been named to succeed JAMES C. PEEBLES as dean of engineering when he retires in August. Dr. Rettaliata, a steam and gas turbine expert, has headed the mechanical engineering department at Illinois Institute since 1945. He is a graduate of Johns Hopkins and also received his doctor's degree from that university in 1936. In 1941 Dr. Rettaliata was cited by the American Society of Mechanical Engineers for his paper, "Combustion Gas Turbine." Twice during the war he visited the European theater of operations, once to investigate jet propulsion aircraft and later to study steam turbines developed by the Germans for submarine operations. In 1944 he was named to the subcommittee on turbines established by the National Advisory Committee for Aeronautics.

STANWOOD W. SPARROW has been elected vice president in charge of engineering for the Studebaker Corp. A mechanical engineering graduate of Worcester Polytechnic Institute, Mr. Sparrow began his career, which has almost entirely been devoted to automotive engineering, by becoming a member of the experimental department of the Stevens-Duryea company, following which he spent four years in the engineering department of the Metz company. During the first world war Mr. Sparrow supervised aviation engine tests in the government altitude laboratory, and in 1918 joined the automotive power plant section of the Bureau of Standards, becoming chief of that section in 1924. His first position with the Studebaker corporation was as a member of its en-



The G-E Electronic Reproducer, which magnetically recreates the full recorded sound, derives its magnetic field from a G-E SINTERED ALNICO 5 permanent magnet.

Announcing... A NEW G-E DEVELOPMENT SINTERED ALNICO 5



Actual size of G-E SINTERED ALNICO 5 permanent magnet used in the G-E Electronic Reproducer is shown in red.

NEW ENGINEERING DEVELOPMENT

SINTERED ALNICO 5, General Electric's newest magnetic material, now enables you to design intricate shapes with higher external energy than ever before. The minimum guaranteed available energy is 3,500,000 gauss oersteds for most sizes and shapes. New G-E SINTERED ALNICO 5 possesses tensile properties several times those of CAST ALNICO 5 and can be produced economically in small size parts. You get better surface finish plus closer dimensional tolerances with new G-E SINTERED ALNICO 5.

NEW DESIGNS POSSIBLE

New SINTERED ALNICO 5 has higher external energy than either SINTERED ALNICO 2 or 4. This makes possible new designs heretofore impossible or impractical. It is especially adaptable where small powerful magnets having high magnetic properties are required. Because of their great stability and external energy, SINTERED ALNICO 5 magnets can save valuable space in your product. You can usually improve your product by re-designing to use high energy G-E SINTERED ALNICO 5. Typical applications now in production which use G-E SINTERED ALNICO 5 include the following: meters, relays, fountain pens, electronic reproducers, and compasses.

ENGINEERING SERVICE

G-E application and development engineers, working closely together, are ready to advise you on new SINTERED ALNICO 5 and other G-E magnetic materials. Our engineers are backed by years of research and the development of thousands of magnetic applications. They will be glad to work with you on your product design. For more information, please mail the coupon shown below.

YOU GET 5 ADVANTAGES

1. Higher external energy than either SINTERED ALNICO 2 or 4.
2. Tensile properties are several times greater than CAST ALNICO.
3. Excellent surface finish.
4. Close dimensional tolerances.
5. Intricate shapes possible.

METALLURGY DIVISION
CHEMICAL DEPARTMENT
GENERAL ELECTRIC COMPANY
PITTSFIELD, MASS.
Please send me:
( ) Technical Report on new SINTERED ALNICO 5.
( ) Bulletin, CO-5, "G-E Permanent Magnets."
NAME..... TITLE.....
COMPANY.....
PRODUCTS MFRD.....
ADDRESS.....
CITY..... STATE.....

PERMANENT MAGNETS

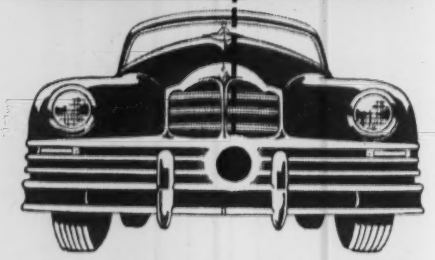
GENERAL ELECTRIC

CD48-V2

Silicone News

DC DOW CORNING SILICONES

Materials to Match Ideas



Packard adopts Houde Torsional Vibration Damper with DC 200 Silicone Fluid to absorb vibration of crankshaft.

Some of the best ideas die for want of the materials necessary to make them practical or for want of the time required to develop them. This might have been the fate of the ideas embodied in the Torsional Vibration Damper shown above. Use of a viscous fluid to smooth out the twisting motion of crankshafts was sound in theory—but impractical because there were no fluids which kept essentially the same consistency in use at high and low temperatures.

Engineers of the Houde Engineering Division of the Houdaille-Hershey Corporation were stymied until they requested samples of DC 200 Fluid in December 1944 and proved to themselves that this Silicone Fluid developed by Dow Corning had exactly the properties they needed. Even so, a great deal of time was required before the device could be perfected and its superiority proved on Diesel engines and finally on the 1948 Packard 8 and DeLuxe 8.

And the story of DC Silicone Fluids as damping media has just begun. We have learned from this and many similar experiences that equally useful applications of the basically different Dow Corning Silicone products may require an equal amount of developmental time. It's none too early to investigate their potential advantages. DC Silicone Resins, Varnishes, Fluids, Lubricants and Silastic* are described in Catalog B 1-15, available from Midland or nearest branch office.

*TRADEMARK FOR DOW CORNING SILICONE RUBBER

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

New York • Chicago • Cleveland • Los Angeles
Dallas • Atlanta
In Canada: Fiberglas Canada, Ltd., Toronto

Dow Corning
FIRST IN SILICONES

Dow Corning Silicone Products Include

FLUIDS
Damping
Hydraulic
Dielectric
Waterproofing
Lubricating
Diffusion Pump
Mold Release

GREASES
High Temperature
Low Temperature
Valve Lubricants
Stopcock
High Vacuum

COMPOUNDS
Ignition Sealing
Antifoam A

RESINS
Electrical Insulating
Laminating
Protective Coatings

SILASTIC*
Molding
Extruding
Coating
Laminating

*Trade Mark
Dow Corning
Corporation

gineering staff when he joined the organization in 1926. He became chief of research and development in 1937 and later chief executive assistant to ROY E. COLE, who has recently retired from the post of vice president in charge of engineering. During the last war, Mr. Sparrow was in charge of production testing of aircraft engines produced by Studebaker. As a research and experimental engineer, Mr. Sparrow is nationally recognized. He has written a number of technical articles and has been active in the Society of Automotive Engineers.

♦

W. HAYWARD GEDDES, associated with United Aircraft Products Inc. for the past seven years, has been appointed its chief engineer.

♦

DR. H. B. OSBORN, associated since 1940 with Ohio Crankshaft Co. as research and development engineer and more recently as sales manager of the organization's Tocco division, has been appointed technical director for that division.

♦

BEN LIVERS has been named assistant chief hydraulic engineer, Pacific division, Bendix Aviation Corp. Previously Mr. Livers was chief engineer, Aireon Mfg. Co.

♦

AUGUST R. MAIER recently was appointed director of engineering of the Oil Well Supply Co. ALEXANDER QUAYLE, formerly assistant chief engineer, succeeds Mr. Maier as chief engineer.

♦

C. W. LAPIERRE, vice president in charge of engineering, American Machine & Foundry Co., has been elected a director of both American Machine & Foundry and its affiliate, International Cigar Machinery Co.

♦

DONALD J. HAWTHORNE has been elected to the newly created post of executive vice president of General Time Instruments Corp. Mr. Hawthorne has been vice president in charge of manufacturing and engineering since 1945. He will continue to direct those operations of the company in addition to his new responsibilities.

♦

D. H. MERRY has been appointed director of quality control engineering at the Detroit engine division, Kaiser-Frazer Corp., Willow Run, Mich. Mr. Merry joined the organization in January, 1946 and participated in the development and adaptation of the six-cylinder Continental engine for use in Kaiser and Frazer automobiles.

♦

FRANKLIN H. FOWLER JR. has joined the staff of Lessells and Associates, Boston, to engage in mechanical engineering consulting work and to conduct fundamental research in the theory of metal fatigue.

♦

D. ROY SHOULTS has advanced from his post of chief engineer of the Glenn L. Martin Co. to that of vice president in charge of engineering, succeeding W. K. EBEL, resigned. Mr. Shoults also will continue as chief engineer until a successor is named.

Dust rides this Cooling Slipstream *OUTSIDE and AWAY*

COLOR STREAMERS trace the fan-driven airstream in this action photo. See how it draws out heat from the radiating fins that provide over 150% more cooling surface—without trapping dust and dirt. Even in a virtual dust bowl of flour, cement, or sand, the Sealedpower ventilating system provides no place, no way for dust and dirt to choke and clog. Only Sealedpower Motors offer this *outside* fin construction.

DOWNTIME IS DESIGNED OUT . . . OF C-W SEALEDPOWER MOTORS

THIS EXCLUSIVE DESIGN gives you years and years of cool, clean operation on the dirtiest jobs without time out to clean out dirt-and-dust-traps common to other totally enclosed motors. Even airborne lint that packs and clogs is no problem. It can be cleared from the air grille of the fan-cowl with a whisk of a brush, while the motor is running.

FRAME IS RUGGED CAST IRON to resist the effects of moisture and corrosive conditions like those in textile finishing and chemical plants. There is no steel to rust.

AVAILABLE IN NEW RATINGS . . . 3 to 40 hp at 1800 rpm. Write for Bulletin SL-300-2 giving full details of this unique Crocker-Wheeler Sealedpower Motor. Also, get complete descriptive data on the general C-W line of AC and DC motors and generators, and flexible couplings.

CROCKER-WHEELER AMPERE, N. J. TRADE MARK REG. U.S. PAT. OFF. DIVISION OF JOSHUA HENDY

CROCKER WHEELER

ELECTRIC MANUFACTURING COMPANY, AMPERE 3, N. J.

A Division of The Joshua Hendy Corporation

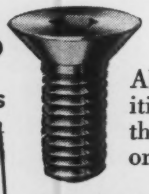
Branch Offices: Boston, Chicago, Cincinnati, Cleveland, Los Angeles, New York, Philadelphia San Francisco, Pittsburgh, Washington, D. C. — Representatives in principal cities.

QUALITY MOTORS AND GENERATORS SINCE 1888

GET HIGHER UNIFORM QUALITY . . . BUY ALLENS

Allen quality starts with the use of Allenoy steel, developed specially for the purpose. The strength of the steel is preserved and reinforced at vital points leaving the steel fibres uncut and intact. Not only is threading to class 3 fit held to extreme accuracy, but *extra* operations assure maximum grip. Heat treatment is regulated to laboratory standards of precision. Quality control is assured by laboratory testing of every batch in addition to the most careful gauging and inspection at the machine. These are some of the reasons for the higher uniform standards of Allen screws. Write us direct for descriptive folders or technical information.

HAVE YOU TRIED
ALLEN HEX SOCKET
FLAT HEAD CAP SCREWS



Allenoy steel plus positive wrenching makes them vastly superior to ordinary cap screws.

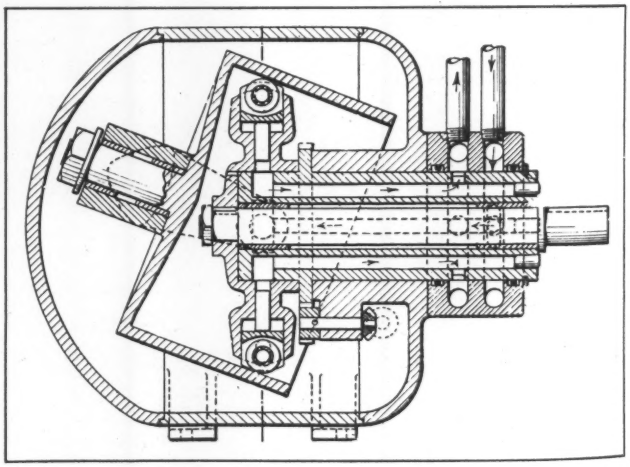
WARNING
Allen-TYPE screws aren't necessarily Allen-MADE. Be sure to get genuine ALLENS. SOLD ONLY THROUGH LEADING DISTRIBUTORS.

ALLEN
ALLEN HEAD
Hartford 2, Connecticut, U.S.A.
NEW YORK, CLEVELAND, DETROIT, CHICAGO, LOS ANGELES

NOTEWORTHY PATENTS

CHATTERING during closing is prevented with the hydraulic check valve covered in patent 2,431,769. Assigned to the Parker Appliance Co. by Arthur L. Parker, the valve is simple in design and relatively small. Once the preset spring pressure of the valve is overcome and the valve head moves off the seat, effective valve-head area is greatly increased, providing rapid opening with minimum pressure drop. In closing, the valve head traps fluid as it moves into the seat recess to provide an effective cushioning action during seating.

CYLINDRICAL ROTOR SHELL of an unusual hydraulic pump design, when adjusted to an angular operating position, provides an elliptical path against which the pistons function. This elliptical path results in double piston strokes and a hydraulically balanced rotor assembly. Surrounding the pump rotor and pistons, the cylindrical thrust member rotates

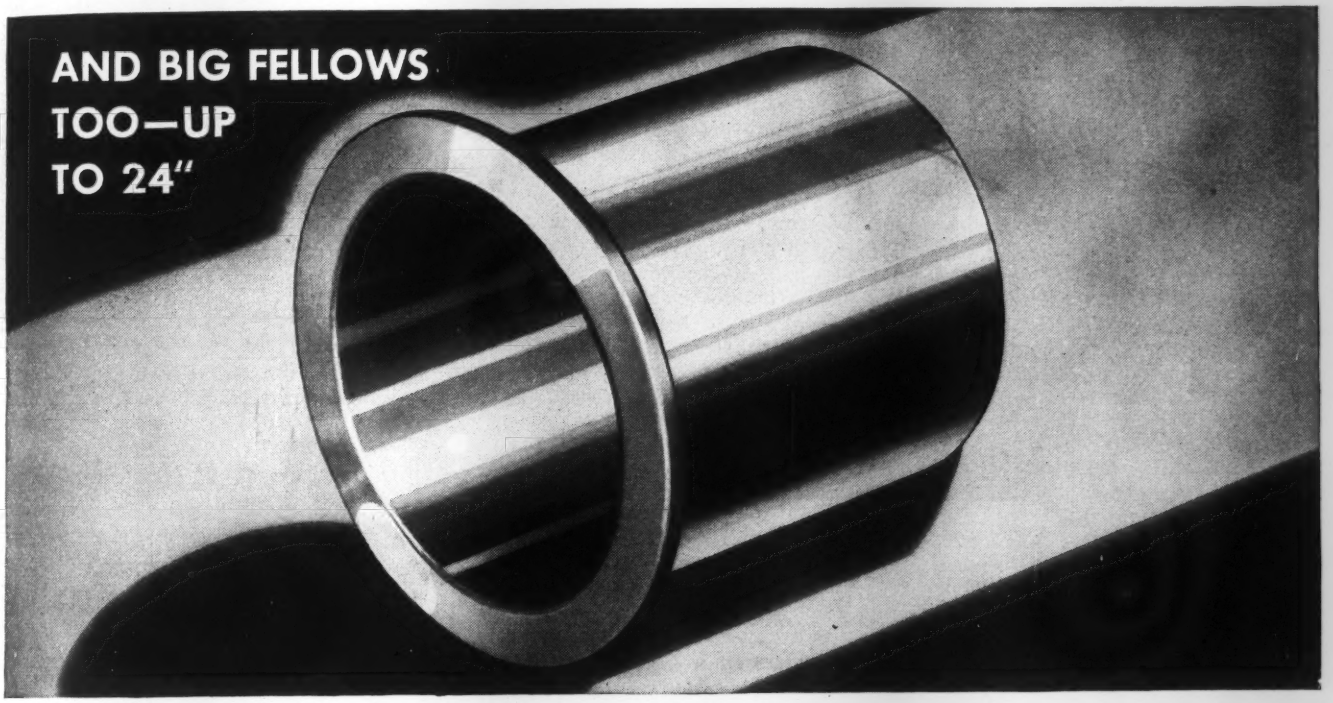


with the cylinder block and pistons and in the same direction, thereby eliminating the usual camming action required. Angular positioning of the cylindrical thrust shell provides a variable elliptical path which offers extremely smooth operation, low wear, and high operating efficiency even at high speeds. Design patented under number 2,420,806 by Carl E. Anderson.

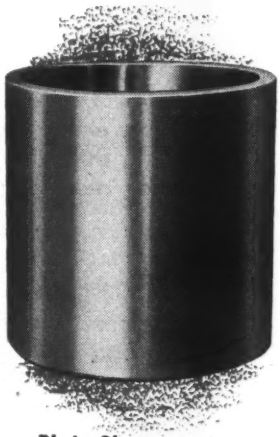
RELATIVE ANGULAR MOVEMENTS that occur between the opposite ends of plain double-helix bi-

OILITE

THE *Oil Cushion* BEARING



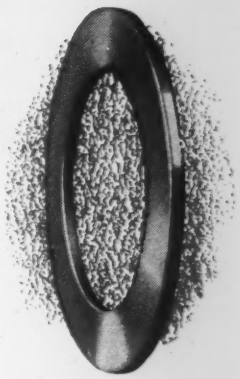
. . . with Automatic Self-Lubrication



Plain Sleeve

OILITE is the heavy-duty OIL CUSHION Bearing built for surplus performance capacity necessary to meet unexpected emergencies. OILITE Bearings are used on all types of equipment from toy trains to heavy locomotives. They furnish metered lubrication without waste. Additional OILITE advantages are:

- First in engineering service.
- Greater plant facilities.
- Larger research staff.
- Representation in every state and Canada.
- 2400 Engineers and Technicians available for counsel.
- Production tools for over 18,000 types and sizes.
- Large Bearings too—up to 24" diameter.
- And OILITE Bearings are not expensive.
- Mail us your blueprints. Address Department "A".



Thrust

AMPLEX MANUFACTURING CO. DETROIT, 31 MICHIGAN

Division of Chrysler Corporation

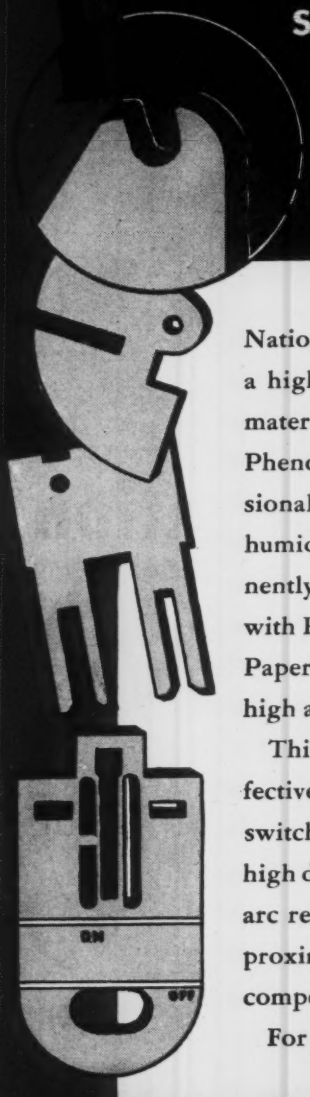
FIELD ENGINEERS AND SUPPLY DEPOTS IN PRINCIPAL CITIES

PRODUCT OF NATIONAL RESEARCH

SWITCH INSULATION

Remarkable
ARC RESISTANCE

DIMENSIONAL
STABILITY



National Switch Insulation is a highly efficient "sandwich" material which consists of a Phenolite core—for dimensional stability even under humid conditions — permanently bonded and molded with Peerless Insulation (Fish Paper) surfaces, to provide high arc (tracking) resistance.

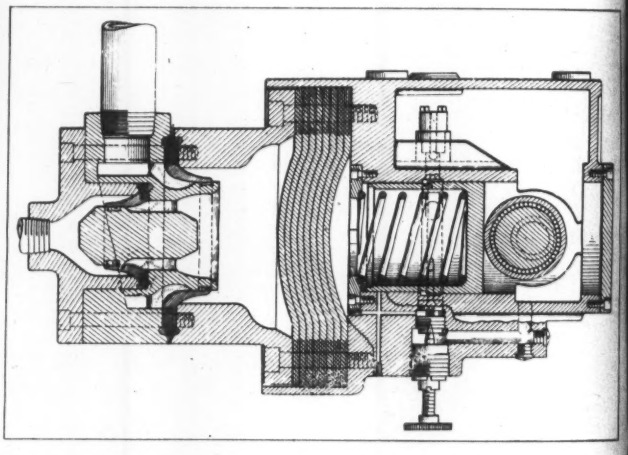
This product is used effectively to insulate electrical switches and equipment where high dimensional stability and arc resistance are required in proximity to current-carrying components.

For full details call or write

NATIONAL VULCANIZED FIBRE CO.
WILMINGTON 99, DELAWARE

metal thermostats are eliminated by a novel design covered in patent 2,425,687. Obviating the manufacturing difficulties and complex calculations ordinarily required in designing such units, this design consists of winding the bimetal strip around a centerline which itself is disposed as a larger or secondary helix. The primary helix is wound or coiled counterclockwise throughout the first half of the secondary helix and clockwise in the second half to attain a unit which compensates with equal simplicity under axial expansion or contraction. Axial compensation for operation by angular twisting can also be obtained. Patent assigned to Metals & Controls Corp., by Unto U. Savolainen.

HYDRAULIC ACTUATION is employed in the operation of a diaphragm pump for liquids covered in patent 2,424,595 assigned to Hydraulic Impact Tool Co., by Charles F. Warren. Driven by roller cam action, the piston of this unusual pump, operating in a reservoir of oil, applies fluid pressure to the circular synthetic-rubber diaphragm to obtain alternate suction and pressure conditions in the pumping chamber. Specially unique is the dual check-valve arrangement which consists of a ring of flexible elastic material with a tapering section having its thick outer edge clamped securely while its inner molded lip forms the valve seating surface.



CONSTANT EXTRUSION SPEED is maintained at a predetermined value during the full working stroke of a press with the circuit outlined in patent 2,426,692. Assigned to Hydropress, Inc., by Francis Katz, this hydraulic circuit arrangement employs an auxiliary cylinder actuated by the press ram, which forces fluid through an adjustable orifice to control the fluid flow to the main ram. Fluid velocity through the preset orifice varies directly with the ram speed, and the pressure variations created by changes in ram speed are used to actuate the diaphragm control of the regulating valve. Automatic regulation of pressing speed is achieved in direct response to the speed of movement of the main ram regardless of the multi-

An Idler Wheel of LORD BONDED RUBBER

assures silent operation and perfect reproduction

in the **BRUSH**

SOUNDMIRROR*

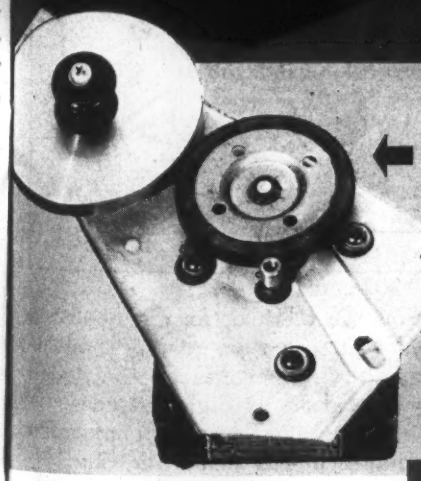
MAGNETIC RIBBON

Home Recorder-Reproducer

The design engineers of the Brush Development Company had a problem . . . they needed an idler wheel for the Soundmirror Magnetic Ribbon Home Recorder-Reproducer. It had to have precise concentricity and to be perfectly quiet in operation . . . it had to give long and trouble-free service.

They found the answer in Lord's facilities for precision control in every step of manufacture, in the perfect rubber-to-metal bond obtained by the Lord process, in the scientific selection of a synthetic rubber that combined abrasion resistance with the necessary resilience.

Rubber, natural and synthetic, with its almost infinite range of controllable properties, offers innumerable opportunities for product improvement. In many years' experience in the production of bonded rubber mountings for vibration control Lord has accumulated a wealth of experience in the application of other bonded rubber components for product improvement. Consult our engineering department for assistance in solving your problems through the use of Lord Bonded Rubber Products.



Successful operation demands perfect concentricity and a permanent rubber-to-metal bond in this idler wheel.

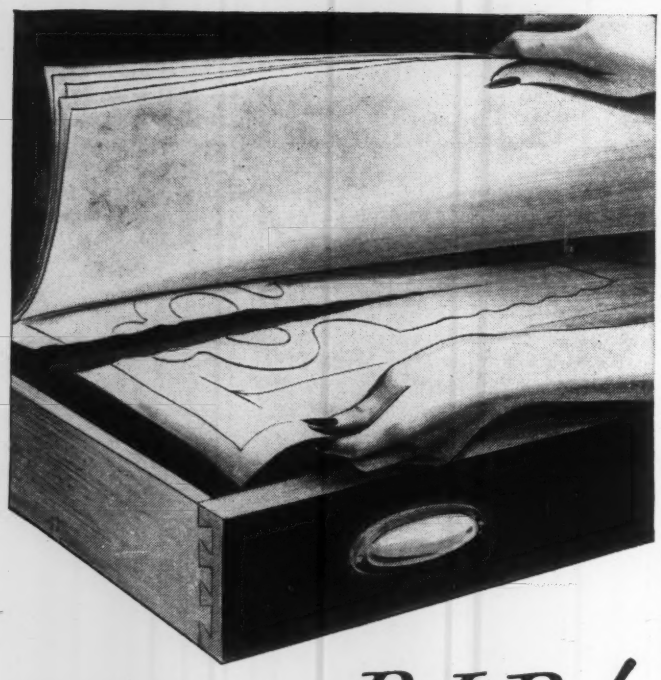
*TRADE MARK REGISTERED

LORD

MAKE GOOD PRODUCTS BETTER

with *Vibration Control*

LORD MANUFACTURING CO. ERIE, PA.



r~r~r~r~RIP!

"Embarrassing is no word for it! The big boss wants prints in an hour. He won't understand that this old tracing is dry and brittle, and hit high C when I tried to pull it out of the cabinet in a hurry. All he'll see will be the patch marks. Wonder why he doesn't insist on Arkwright."

Arkwright has a world-wide reputation for staying clear, clean and pliable, year after year ... nc ghost-producing spots ... no tear-causing brittleness. Special mechanical all-the-way-through processing gives it this ability to laugh off the years. A perfect print was made recently from an 80-year-old tracing on cloth made by the same process now employed by Arkwright.

Why not try Arkwright? See for yourself what a difference there is. Generous working samples free upon request. Arkwright Finishing Company, Providence, Rhode Island.

All Arkwright Tracing Cloths have these 6 important advantages

1. *No surface oils, soaps or waxes to dry out, stain and cause brittleness.*
2. *Erasures re-ink without "feathering" or "creeping".*
3. *Prints are always sharp and clean.*
4. *No pinholes or thick threads.*
5. *Tracings never discolor or become brittle.*
6. *Mechanical processing creates permanent transparency.*

Arkwright

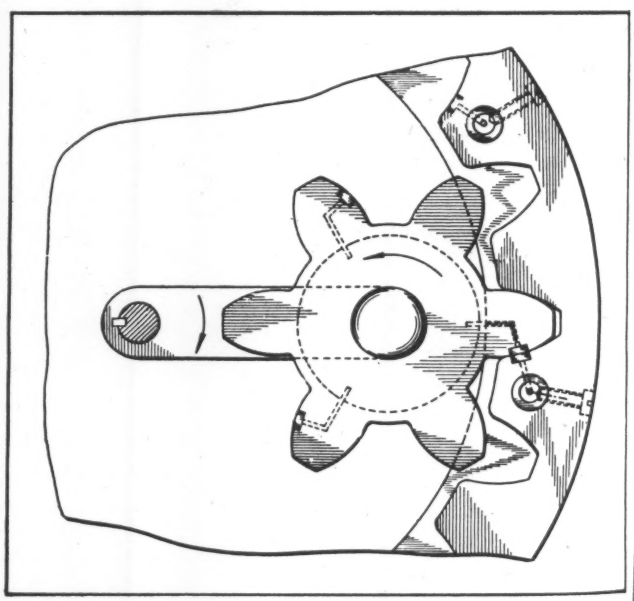
TRACING CLOTHS

AMERICA'S STANDARD FOR OVER 25 YEARS

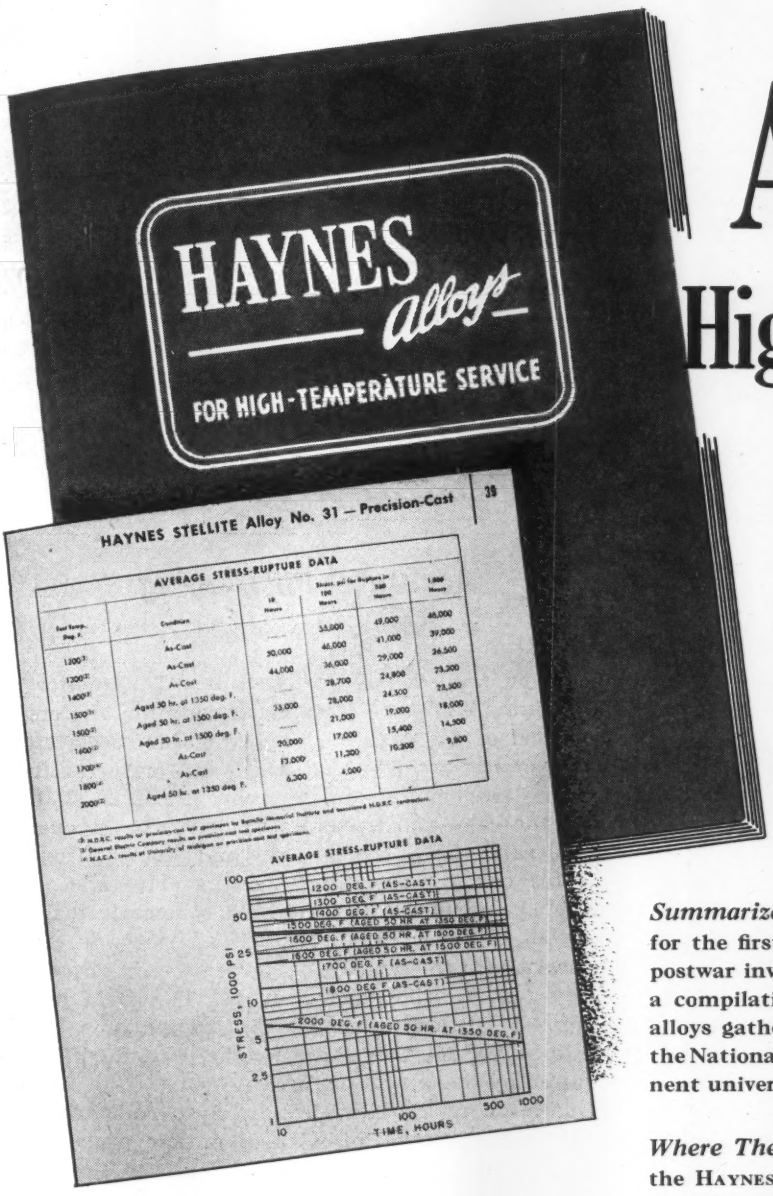
tude of variables such as length of billet, extrusion temperature, or die shape.

NEW SENSING DEVICE, for governing the speed of fluid-driven turbine motors, supplants the use of control devices such as fly weights, springs, etc., on rotors which operate at speeds exceeding the limits of mechanical governors. Suitable for applications where peripheral speeds exceed, say, five miles per minute, this mechanism controls a throttle valve in the power supply medium to govern speed by sensing or measuring the amount of radial expansion created in the rotor by centrifugal forces. Because this radial expansion is proportional to speed of rotation, precise control by means of the well-known air-jet principle can be exercised over the driving medium. Covered by patent 2,426,045 assigned to Onsrud Machine Works by Rudolph F. Onsrud.

INCREASED FLASHOVER distance and consequent reduction in size is achieved in a novel ignition distributor design covered in patent 2,427,583 assigned to United Aircraft Corp. by E. K. von Mertens. Embodying the principle of planetary gearing, the distributor comprises a fixed ring gear having magneto and spark plug terminals which are electrically connected in timed relation to the engine cycle by a contactor or conductor on the teeth of an engine-driven planet which meshes with the ring gear. Eliminating carbon brushes and special contacts, the design permits satisfactory operation at high altitudes, requires no ventilation, and makes possible elimination of air by operation submerged in insulating oil.



ELIMINATION of the need for an accumulator in hydraulic circuits such as those used on aircraft is



A New Book on High-Temperature Alloys

Contains Complete Information on Physical and Mechanical Properties, Age-Hardening, and Fabricating Procedures.

Stress-rupture (above) and short-time tensile properties for each alloy are presented in tables and charts. Data on chemical composition and physical and mechanical properties are included for each of eight HAYNES alloys.

HAYNES Alloys
for High-Temperature Service
87 pages — 51 tables — 58 charts
44 photomicrographs

Summarizes Wartime and Postwar Investigations: Here, for the first time, are summarized the many wartime and postwar investigations of the new super-alloys. This book is a compilation of data on eight HAYNES high-temperature alloys gathered by the National Defense Research Council, the National Advisory Committee for Aeronautics, and prominent university and industrial research laboratories.

Where These Super-Alloys Are Used: The major use for the HAYNES high-temperature alloys, until now, has been in the aircraft field. They have been used successfully in such parts as turbosuperchargers, turbine blading, rotors, cabin heaters, and exhaust stacks. Now they are also being put to use in the chemical, oil-refining, and heat-treating industries—where good high-temperature properties are likewise essential.

Who Should Have a Copy of This Book: Every engineer and metallurgist who designs or specifies equipment for service at elevated temperatures should have a copy of this book. Design engineers, particularly, will find it a useful guide in the selection of alloys to meet the exacting requirements of high-temperature service.

HAYNES Alloys

Haynes Stellite Company
UCC
Unit of Union Carbide and Carbon Corporation

The registered trade-marks "Haynes," "Haynes Stellite," "Hastelloy," and "Multimet" distinguish products of Haynes Stellite Company.

USE THIS CONVENIENT COUPON

Haynes Stellite Company,
721 S. Lindsay St.,
Kokomo, Indiana

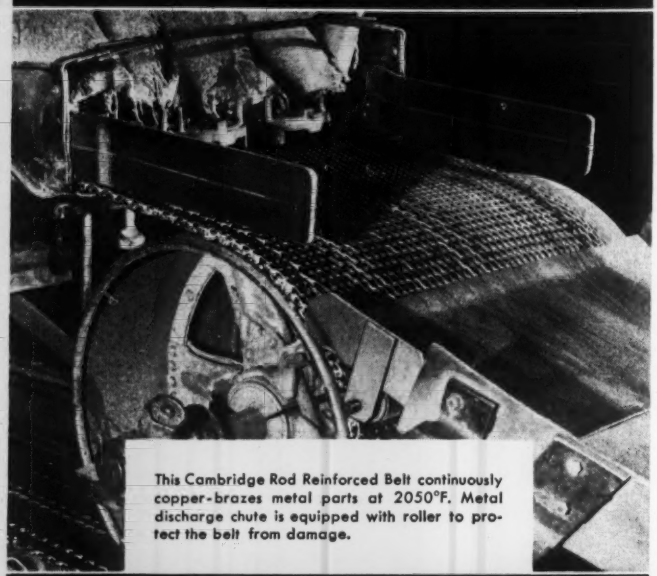
Please send me, without obligation, a copy of "HAYNES Alloys for High-Temperature Service."

Name..... Title.....

Company.....

Address.....

HOW *Cambridge*
WOVEN WIRE
CONVEYOR BELTS
REDUCE
Handling and Maintenance



This Cambridge Rod Reinforced Belt continuously copper-brazes metal parts at 2050°F. Metal discharge chute is equipped with roller to protect the belt from damage.

BOOST
Production Rates

The moving belt permits *continuous* treatment or movement without time-wasting stops at machine stations . . . replaces costly manual labor for handling materials. In most cases one loader is adequate to feed the belt.

And maintenance costs fade because Cambridge woven wire conveyor belts are specially engineered from the particular metal or alloy . . . to the particular mesh or weave . . . that best suits your individual case.

FREE BOOK! "Woven Wire Conveyor Belts for Industrial Applications". 56 pages, illustrated, describing Cambridge Belt Construction and use. Valuable data for all plant operating men. Write for your copy now!

Call in a Cambridge engineer today to discuss the proper belt type for your plant. There's a Cambridge Sales Engineering office near you.

Cambridge Wire Cloth Co.
Department A • Cambridge 5, Maryland

SALES OFFICES IN: BOSTON NEW YORK • BALTIMORE
PITTSBURGH • DETROIT • CHICAGO • SAN FRANCISCO • ST. LOUIS

accomplished with a new valve covered in patent 2,431,944. Assigned to Borg-Warner Corp. by J. A. Lauck and R. G. Holt, the valve delivers hydraulic fluid from a continuously operating pump to the units being actuated. A special arrangement holds the manual valve lever in position until pressure build-up takes place, indicating that the desired movement has been accomplished, automatically returning the valve to neutral, trapping the fluid in the actuator, and unloading the pump. The valve can be used individually or arranged in series to attain a succession of operations. Connected in series, the valves automatically sequence when set to "on" position. The first, on closing, releases pressure to actuate the second, etc., without any overlapping of operations to lower the pressure delivered to the actuators.

Accurate Positioning

(*Concluded from Page* 144)

celeration needed. A Rototrol speed regulator of the counter emf type is used to maintain the creeping speed of the car. It provides a flat speed-torque characteristic at low speed and low armature voltage of the drive motor and thereby prevents stalling. Since the cage and transfer car drives never operate at the same time, the m-g set and Rototrol for the transfer car are used for the cage drive also.

The sketch shows a simplified schematic diagram for the transfer car drive. The armature circuit connections are typical of a reversing adjustable voltage or Ward Leonard drive. The field of the generator is excited across the exciter in a bridge circuit in which the excitation may be modified as required by the output of the Rototrol.

Operation of the Rototrol involves comparison of the motor counter emf with a voltage proportional to the speed desired. The back emf of the motor is proportional to its speed and is taken as the terminal voltage of the motor minus the *IR* drop in the armature. It is measured by the combination of voltage and current fields of the Rototrol. Any difference between the measured back emf and the reference voltage causes the Rototrol output to change in such a manner that the generator voltage changes to correct the motor speed. It should be noted that the Rototrol is required to provide only the regulating excitation to the generator.

Transfer car drive and cage drive are controlled by an operator who rides on the transfer car and controls the drive by pushbuttons. By means of a pushbutton he selects the oven to which the car is to go and from there on the operation is under the control of limit switches which first initiate a slow-down to creeping speed and then the stop from creeping speed.

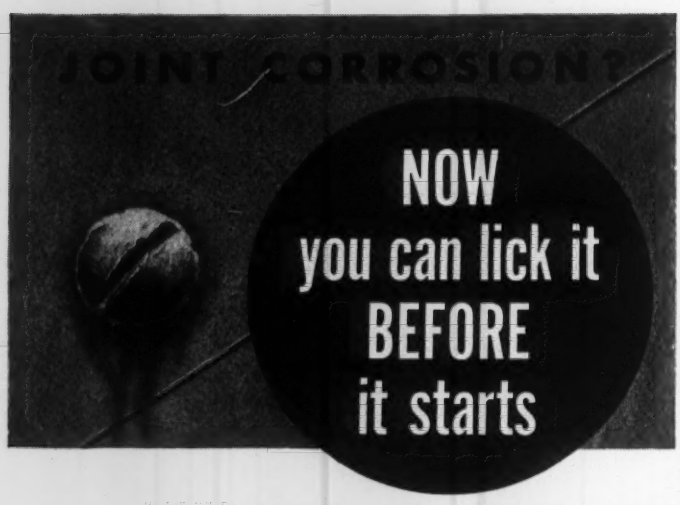
The photograph shows the arrangement of the mechanical and electrical equipment on the car and cage. A rack and pinion drive is provided for the transfer to eliminate errors in spotting due to wheel slippage which might occur if a conventional traction drive were used.

FOR ECONOMICAL PRECISION PARTS OF MACHINE TOOLS, JIGS AND MOLDS USE J&L COLD FINISHED FLATS

The size accuracy, surface finish and improved physical properties of Cold Finished flats make them applicable for many uses without extensive machining. They are economically made into slides for machine tools, parts for jigs and fixtures and molds for rubber and plastic. J&L Cold Finished flats are available in a variety of grades—in sizes from 6″ to 14 5/8″ from your nearest J&L Warehouse or distributor.

JONES & LAUGHLIN STEEL CORPORATION

PITTSBURGH 30, PENNSYLVANIA



FASTEN ALUMINUM WITH ALUMINUM

Everywhere that aluminum meets aluminum in your assemblies, Alcoa Fasteners eliminate galvanic corrosion, resist common corrosion, prevent streaking, give you more fasteners per pound. A complete line is available—sheet metal, wood and machine screws with slotted or Phillips head; rivets, bolts, hex nuts, wing nuts, cap nuts, castle nuts, washers. For a strong, tight, corrosion-resistant joint, fasten aluminum with Alcoa Aluminum Fasteners.

WRITE FOR FREE SAMPLES
Samples of Alcoa Aluminum Fasteners sent free when requested on your letterhead. Please specify type, length and size.

ALUMINUM COMPANY OF AMERICA, 617 Gulf Building, Pittsburgh 19, Pennsylvania.

ALCOA *Aluminum* FASTENERS

BUSINESS AND SALES BRIEFS

RELIANCE ELECTRIC & ENGINEERING CO. of Cleveland and the Philadelphia Gear Works, Inc. are co-operatively engaged in the manufacture and sale of a new gearmotor. Philadelphia Gear Works will cut the gears, while Reliance will supply the motors. Both companies will sell the finished product.

♦

Hanna Engineering Works has announced the opening of a direct factory office in Detroit. Located at 1609 Industrial Bank Building, the office will be served by Frank A. James and W. J. Renaud. Concurrently, John Furey has been named district representative for the New England States with offices at 264 W. Brimfield Road, Wethersfield, Conn.; and Scott Equipment and Engineering Co., 612 Imo Drive, Dayton, has been named to represent the Hanna company in southern Ohio.

♦

Allen-Bradley has recently acquired new and larger quarters for its Detroit office. Located at 11100 E. Warren Ave., the office is under the supervision of J. D. Petersen.

♦

Coupling divison of John Waldron Corp. is now managed by Henry A. Anderson. The new manager will make his headquarters at the main office of the corporation in New Brunswick, N. J.

♦

Small Lot Stamping Co. of 1025 W. Blancke St., Linden, N. J. has recently been formed, with K. Peterson as president. The company will produce custom-made stampings from ferrous and nonferrous metals, in small lots.

♦

Carpenter Steel company's board of directors has elected Frank P. Palmer president to succeed J. Heber Parker who was named chairman of the board. Mr. Palmer was formerly vice president in charge of sales for the steel company.

♦

Burgess-Norton Mfg. Co. has announced the recent election of several officers. President of the company is C. M. Burgess; F. E. Burgess is executive vice president and Harry S. Smith is a newly elected vice president.

♦

Ross Operating Valve Co. has moved into new quarters at 120 E. Golden Gate, Detroit. This will increase manufacturing floor space 30 per cent.

♦

Hydro-Line Mfg. Co. has appointed Frank G. Bastable as sales representative in the midwest territory. Mr.

WHS WINSMITH SPEED REDUCERS

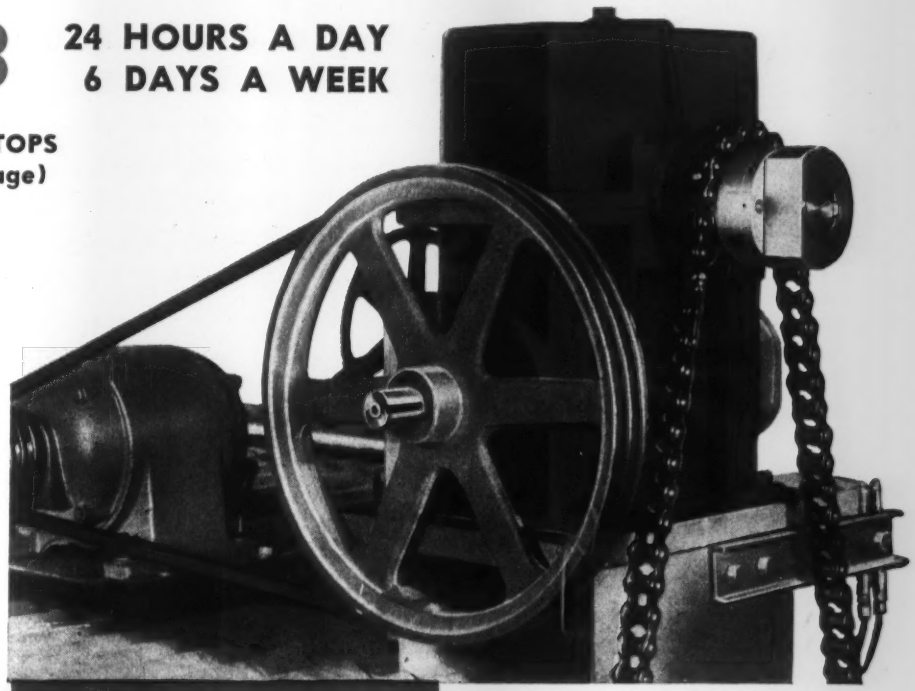
SPEED REDUCER *Dependability*

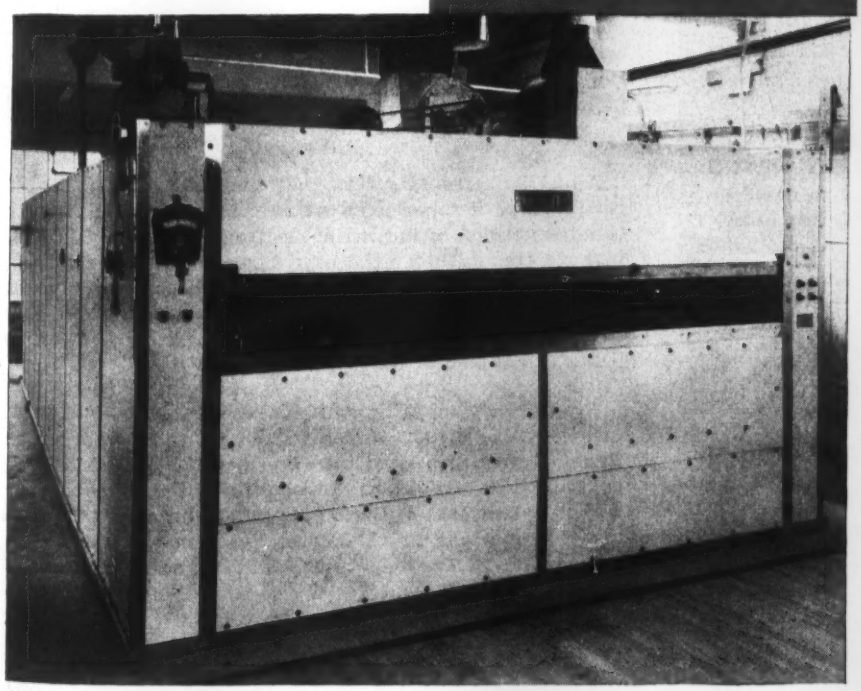
ON THE JOB

24 HOURS A DAY
6 DAYS A WEEK

60 STARTS and STOPS PER HOUR (Average)

A regular stock model No. 8B WINSMITH Speed Reducer, 60 to 1 ratio, helps assure perfect baking conditions, economy of operation and precision timing in this JaWin Oven, made by JaWin Manufacturing Co. of Brooklyn, N. Y.





WINSMITH'S 47 year-old, enviable reputation for sturdy *dependability* stems from excellent designing, insistence on quality materials, most modern production methods and fine precision workmanship. Let us translate these "generalities" into specific, detailed proof. Send for our latest catalog, showing in detail "The Most Complete Line of Speed Reducers from Any One Source". Better still, let our Engineering Dept. help you solve your individual speed reduction problem—no obligation.

MEMBER OF AGMA

WHS WINSMITH SPEED REDUCERS

WINFIELD H. SMITH CORPORATION

16 ELTON STREET . . . SPRINGVILLE . . . ERIE COUNTY . . . NEW YORK

USE THE NYLON

HEYCO

STRAIN RELIEF BUSHING

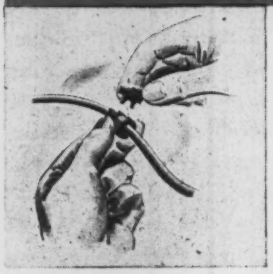
to anchor the cord set to your electrically operated

MACHINES, EQUIPMENT & APPLIANCES

TWO STANDARD HEYCO TYPES

. . . for all wire sizes

● The Nylon Heyco is an insulating grommet that is snapped into a hole in the chassis of a product. It anchors the cord set firmly to the chassis and imparts a positive non-slip grip—it does not injure the wire. Product life is greatly increased by preventing all strain on terminal connections as well as preventing cord wear at chassis entrance.



IT'S EASY TO APPLY HEYCO

1. Slip HEYCO on wire.
2. Snap HEYCO into hole.

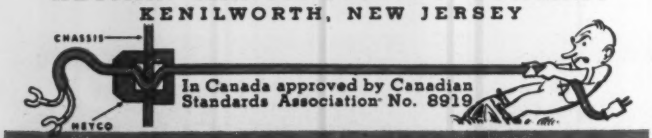
Here's what Heyco does-

1. Absorbs cord pull, push and torque
2. Insulates wire from chassis
3. Prevents wire from fraying
4. Eliminates tying wire knots
5. Improves product appearance at low cost

TEST SAMPLES WILL BE SENT ON RECEIPT OF WIRE SPECIFICATIONS

HEYMAN MANUFACTURING COMPANY

KENILWORTH, NEW JERSEY



In Canada approved by Canadian Standards Association No. 8919

HEYCO ELIMINATES STRAIN ON TERMINALS!

Bastable is vice president of Rockford Automotive Industries.

♦

Timken Roller Bearing Co. has recently leased 50,000 square feet of manufacturing space in which to consolidate all its Zanesville, Ohio operations.

♦

Morse-Formsprag sales department, a sales-manufacturing consolidation of the Morse Chain Co. Div. of Borg-Warner Corp. and Formsprag Co., has been formed with headquarters at 7601 Central Ave., Detroit 8.

♦

Link-Belt Co. has announced a number of recent sales appointments. These include the placing of Emmart LaCrosse Jr. in charge of the Louisville, Ky. sales office. He will make his headquarters at 136 S. 4th St. In North Carolina, Thomas H. Appleton has been appointed district sales manager with offices at 617 Johnston Bldg., Charlotte 2. William H. Kinkead is in charge of the new Wilmington, Del., office. His headquarters are at 805 Orange St., Wilmington 43.

♦

Chicago Metal Hose Corp. has purchased the Wheelock Mfg. Co. of St. Johnsbury, Vt. The purchased company will remain at its present location and will function as the Wheelock Mfg. Div. of the parent organization.

♦

Pyro Plastics Corp., injection molder, has removed its facilities from the Westfield, N. J. plant to larger quarters in Union, N. J. The new factory occupies over 40,000 square feet of floor space.

♦

Flexible Tubing Corp. has been organized with Frederick K. Daggett as president, to manufacture flexible tubing. Mr. Daggett was formerly sales and engineering manager of the Spiratube Div. of Warner Brothers Co.

♦

Allis-Chalmers Mfg. Co. and the RCA Victor Div. of Radio Corp. of America have concluded an arrangement for the distribution of industrial electronic equipment of RCA manufacture. Under the new agreement, Allis-Chalmers will distribute RCA high-frequency heating equipment and metal detectors in addition to its own line of electronic heating equipment.

♦

Tyson Bearing Corp. of Massillon, Ohio, has announced several new appointments in its sales organization: Newly appointed vice president in charge of sales is George C. McMullen. In charge of the mid-west territory is Herschel J. Deal, vice president, who will make his headquarters in Chicago. New general sales manager is W. H. Oexle, formerly district sales manager of the L. S. Starrett Co.

♦

United States Rubber company's mechanical goods division has appointed H. A. Lundberg as Syracuse district sales manager. Mr. Lundberg's territory will cover such cities as Rochester, Utica, Troy, Schenectady, Binghamton and Elmira.

♦

Fuller Mfg. Co. has announced the recent purchase of complete facilities of Reed Foundry and Machine Co.,

Crown Cork and Seal Company, Baltimore, Md., uses austenitic chromium-nickel stainless steel to assure the sanitation, durability and trouble-free performance of their CEMAC 28 unit. Easily cleaned, this stainless steel is highly resistant to foodstuffs, atmosphere, most organic and a great many inorganic chemicals, and to dyes and sterilizing solutions.

Use of STAINLESS STEEL.... *minimizes "CLEAN-up" time*

and CUTS MAINTENANCE COSTS, *too!*

You can save money—and time too—because of the ease with which this equipment can be cleaned.

The rotary vacuum filler-capper, shown above, is equipment of this kind. It saves money, time and labor, *day-after-day.*

Easy to clean and keep clean, it also combats wear and general abuse because it's made of chromium-nickel austenitic stainless steel.

Corrosion-resistance combined with high strength make chromium-nickel stainless steel an ideal material for equipment. Considerably stronger than plain carbon steel, it permits cutting bulk and deadweight without sacrificing strength or durability. In addition it may be readily formed, and is easy to weld.

Leading steel companies produce stainless steel containing nickel in tubular, sheet and strip form. A list of the sources of supply will be furnished on request.

EMBLEM OF INCO SERVICE
TRADE MARK

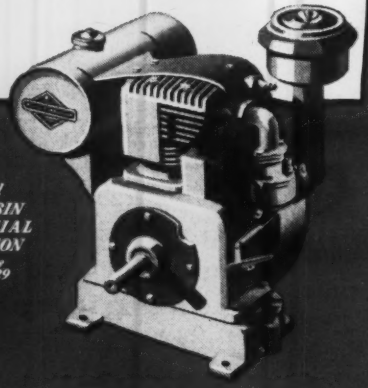
Over the years, International Nickel has accumulated a fund of useful information on the properties, treatment, fabrication and performance of engineering alloy steels, stainless steels, cast irons, brasses and bronzes and other alloys containing nickel. This information is yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

4 CYCLE
BRIGGS & STRATTON
GASOLINE ENGINES

Experience
Skill
Facilities

BUILD THE WORLD'S FINEST
AIR-COOLED ENGINES



Attend
WISCONSIN
CENTENNIAL
EXPOSITION
Milwaukee
August 7-29

★ AIR-COOLED POWER

Briggs & Stratton plants are equipped with the most modern machines, tools, and inspection facilities, designed for precision mass production. Operating this equipment are thousands of experienced and skilled men and women who take pride in their workmanship, and the part they have in building "The World's Finest Air-Cooled Gasoline Engines."

The record established by over 3½ million Briggs & Stratton engines, used in all parts of the world, is gratifying proof of their unequalled, built-in dependability.

When you specify Briggs & Stratton Air-Cooled Power, you are assured maximum engine performance year after year.

BRIGGS & STRATTON CORPORATION, Milwaukee 1, Wisconsin, U. S. A.

Kalamazoo. Newly acquired foundry has a capacity estimated at 15 tons of gray iron castings per day.

♦

Aro Equipment Corp. has recently elected Walter C. Leitch vice president and general manager. Mr. Leitch was formerly associated with Gilbert and Barker Mfg. Co. of Springfield, Mass.

♦

Joseph T. Ryerson & Son Inc. has completed the construction of a new steel service plant in the San Francisco area. Located at Emeryville, Calif., the plant will provide distribution of bars, plates, sheets and special steel as well as babbitt metal and nonmetallic bearings. Manager of the new plant is Wayne D. Dukette, former manager of the Cincinnati facility.

♦

Wagner Electric Corp. has transferred Fred Pasher, former manager of its Cleveland branch, to the Dallas branch where he will serve in the same capacity. Elmer Gent will replace Mr. Pasher as manager of the Cleveland office.

♦

A. O. Smith Corp. has announced the appointment of L. M. Keating as executive administrator of the company's southwest district office in Houston, Texas. Mr. Keating replaces B. F. Bart who died recently.

♦

Lukens Steel Co. has named Andrew J. Lacock as New York district manager of sales. Mr. Lacock will be in charge of the district sales for Lukens as well as for its divisions, By-Products Steel Co. and Lukenweld.

♦

Phosphor Bronze Corp. of Philadelphia has recently purchased the assets of the Phosphor Bronze Smelting Co. Manufacture of the latter organization's trade-name products will not be affected. The manufacturing personnel will remain the same.

♦

Kurz-Kasch Inc. has announced the appointment of H. J. Kasch Jr. as district supervisor of its Indiana territory. This territory will cover all of the state with the exception of the extreme northern sector and three counties in the south-western corner.

♦

Cutler-Hammer Inc. has moved its Atlanta district sales office to new quarters. New location is 714 Spring St., N. W., where improved and expanded facilities are provided.

♦

Reynolds Metals Co. has appointed two new distributors of its aluminum mill products. The appointments include the Hamilton Steel Co., 12875 Taft Road, Cleveland and the Arthur C. Harvey Co., Harvey Steel Road, Allston District, Boston.

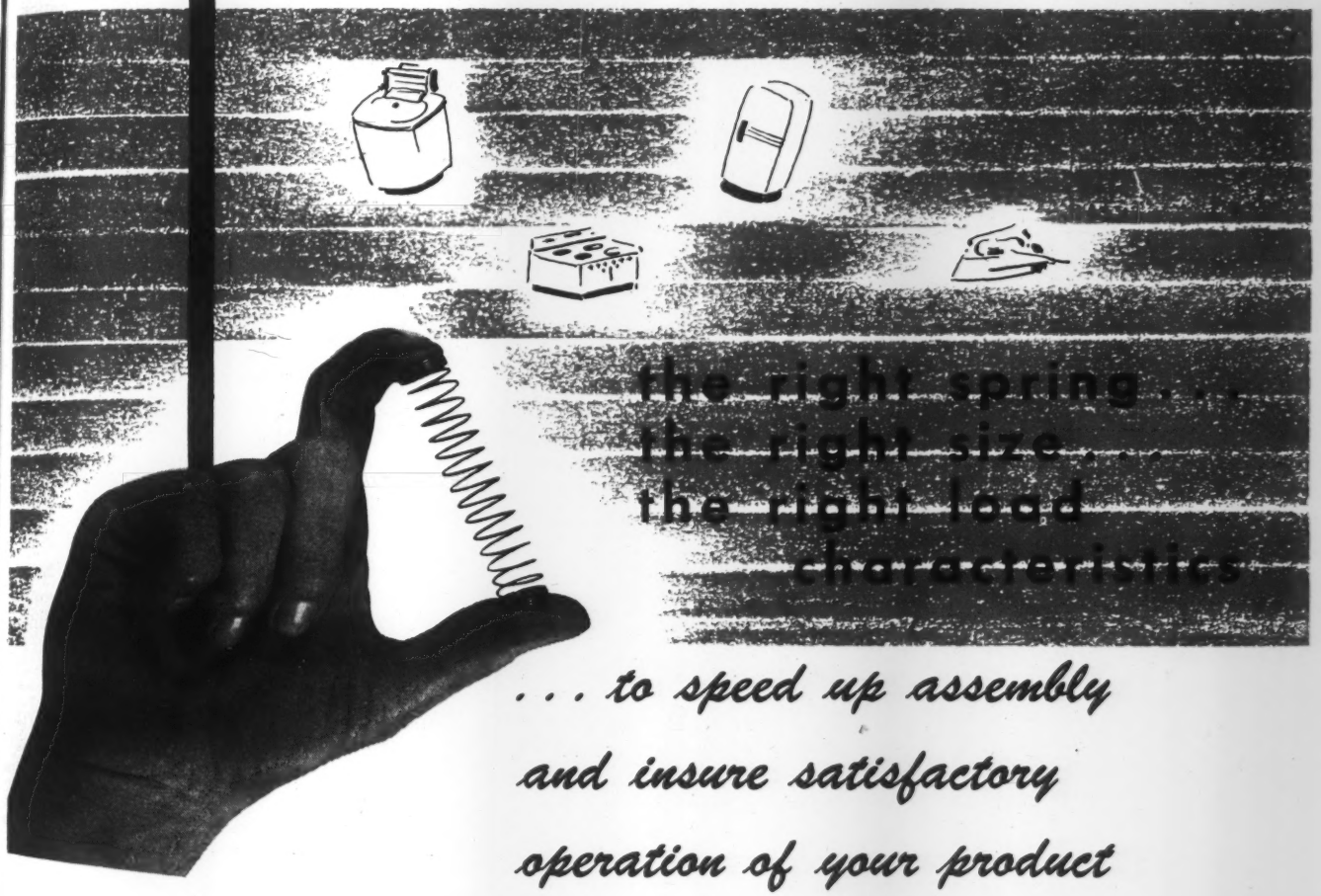
♦

Fafnir Bearing Co. has elected Maurice Stanley chairman at a recent meeting of the board of directors. Stanley M. Cooper succeeds Mr. Stanley as president of the company.

♦

Keystone Carbon Co. has appointed a new sales representative for its northern Ohio territory. The new representative, Edwin J. Lewis, will make his headquarters at 9348 Gaylord Ave., Cleveland. At the same time,

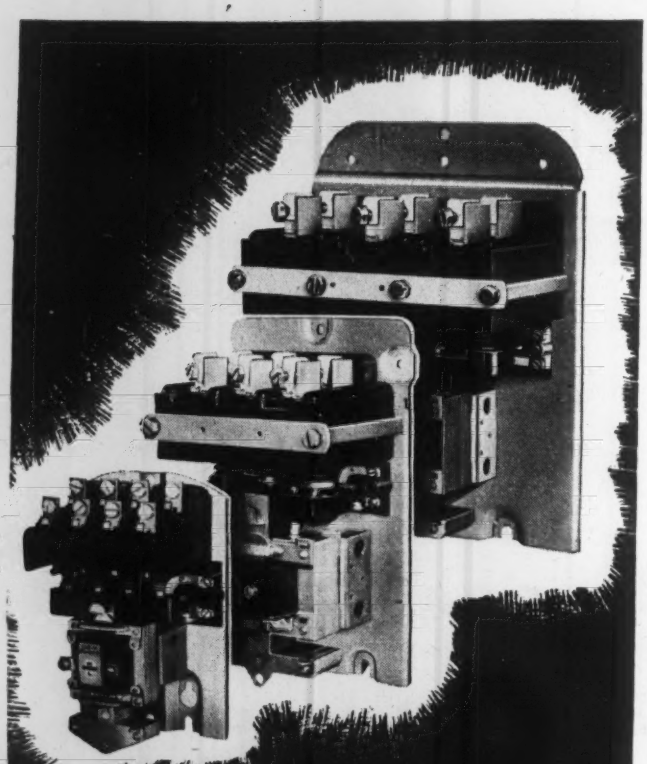
. . . At Accurate



. . . to speed up assembly and insure satisfactory operation of your product

Production conscious Accurate engineers know the importance to you of having all your springs *exactly right.* They know that uniform springs which precisely meet your specifications simplify and cut losses due to rejects. Write for details, today.

ACCURATE SPRING MFG. COMPANY
3813 W. Lake Street • Chicago 24, Illinois



NOW
there are three!

WHERE BASIC DESIGNS IN ELECTRIC CONTROLS ARE RESULT-ENGINEERED FOR YOU

Sizes 1, 2 and 3 of Ward Leonard's new Solenoid Contactors are now available

The advantages of Ward Leonard's recently introduced A-C Solenoid contactor can now be obtained in 2 and 3 pole combinations rated up to 100 amperes.

All these sizes provide "Result-Engineered" features which you can't afford to overlook. Let us point them out to you . . . Write for our Bulletins 4451, 4452, 4453 and be convinced. Ward Leonard Electric Co., 58 South St., Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD
ELECTRIC COMPANY
RESISTORS · RHEOSTATS · RELAYS · CONTROL DEVICES

Gerald G. Fellows was appointed New England representative, with headquarters in Hartford, Conn.

♦

Meehanite Metal Corp. has announced that three foundries operated by I. G. Grawoig & Associates are now in production of Meehanite castings. The associated companies producing these castings are: The American Well Works, Aurora, Ill.; U. S. Challenge Co., Batavia, Ill.; and Hercules Foundry Div., U. S. Challenge Co., Centerville, Iowa.

♦

National Association of Relay Mfrs. has announced the appointment of five members to its committee on standards and nomenclature for 1948. The members are: J. E. Mossman, Phillips Control Corp., Chairman; E. H. Gillette, Allied Control Corp. Inc.; F. W. Falck Jr., Advance Electric & Relay Co.; R. M. Brumfield, Potter and Brumfield Mfg. Co. Inc.; and F. F. Rowell Sr., Guardian Electric Mfg. Co.

♦

Manhattan Rubber Div. of Raybestos-Manhattan has appointed R. F. Teeling as manager of the local sales branch. Mr. Teeling was formerly assistant manager of the branch.

♦

Delco Products Div. of General Motors Corp. has a new branch office in Cleveland. Under the management of S. W. Blanton, the office is located in the Terminal Tower Bldg.

♦

Vickers Inc. has expanded its application engineering facilities by the appointment of two new men to its staff. Fred V. Gieryn is now manager of the Rochester office located in the Genessee Valley Trust Bldg., 45 Exchange St., Rochester 4. In Oklahoma, James W. Kelley is sales engineer with offices in the Thompson Building, 20 E. 5th St., Tulsa 3.

♦

SKF Industries Inc. has announced that its branch office at Charlotte, N. C. has become a district headquarters with a territory embracing North and South Carolina, and portions of southern Virginia, eastern Tennessee and northern Georgia.

♦

Purchase of American Relay and Controls, Inc. of 2555 W. Diversey Ave., Chicago, has been made by David T. Siegel, Chicago manufacturer. New location of the firm is 4900 W. Flournoy St., Chicago 44.

♦

Previously secretary and general counsel of SKF Industries, Charles P. Collins has been elected president and a director of the Norma-Hoffmann Bearings Corp.

♦

Offices and factory of Automatic Switch Co., formerly in New York City, have been moved to Orange, N. J. New address is 391 Lakeside Ave.

♦

General Controls Co. has announced the appointment of E. B. Maire as sales manager of a number of midwestern, southern and eastern branch offices. Mr. Maire will supervise the operation of offices in Boston, Phila-

delphia, Pittsburgh, Birmingham, New York, Detroit, Cleveland and Chicago.

♦

National Association of Relay Manufacturers have re-elected Ralph T. Brengle president. Mr. Brengle is associated with Potter and Brumfield Sales Co.

MEETINGS AND EXPOSITIONS

May 20-21—

Society of the Plastics Industry. Annual meeting to be held at Atlantic City, N. J. Additional information may be obtained from the headquarters of the society, 295 Madison Ave., New York 17. William T. Cruse is executive vice president.

May 20-22—

American Society of Mechanical Engineers. Oil and Gas Power division meeting to be held at the New Jefferson Hotel, St. Louis, Mo. C. E. Davies, 29 West 39th St., New York 18, is secretary.

May 27-29—

Society for Experimental Stress Analysis. Spring meeting to be held at the Roosevelt Hotel, Pittsburgh. W. M. Murray, P. O. Box 168, Cambridge 39, Mass. is secretary-treasurer.

May 30-June 5—

American Society of Mechanical Engineers. Semiannual meeting to be held at the Hotel Schroeder, Milwaukee. C. E. Davies, 29 West 39th St., New York 18, is secretary.

May 31-June 2—

American Society of Refrigerating Engineers. Thirty-fifth spring meeting to be held at the New Ocean House, Swampscott, Mass. David L. Fisk, 40 West 40th St., New York 18, is secretary.

June 6-11—

Society of Automotive Engineers. Summer semiannual meeting to be held at French Lick Springs Hotel, French Lick, Ind. John A. C. Warner, 29 West 39th St., New York 18, is secretary and general manager.

June 7-9—

American Gear Manufacturers Association. Thirty-second annual meeting to be held at The Homestead, Hot Springs, Va. Newbold C. Goin, Empire Bldg., Pittsburgh 22, is executive secretary.

June 14-18—

American Society for Engineering Education. Fifty-sixth annual meeting to be held at the University of Texas, Austin, Texas. Additional information may be obtained from Prof. Arthur B. Bronwell, secretary of the society, Northwestern Technological Institute, Evanston, Ill.

June 17-19—

American Society of Mechanical Engineers. Applied Mechanics division meeting to be held at Illinois Institute of Technology, Chicago. C. E. Davies, 29 West 39th St., New York 18, is secretary.

June 21-25—

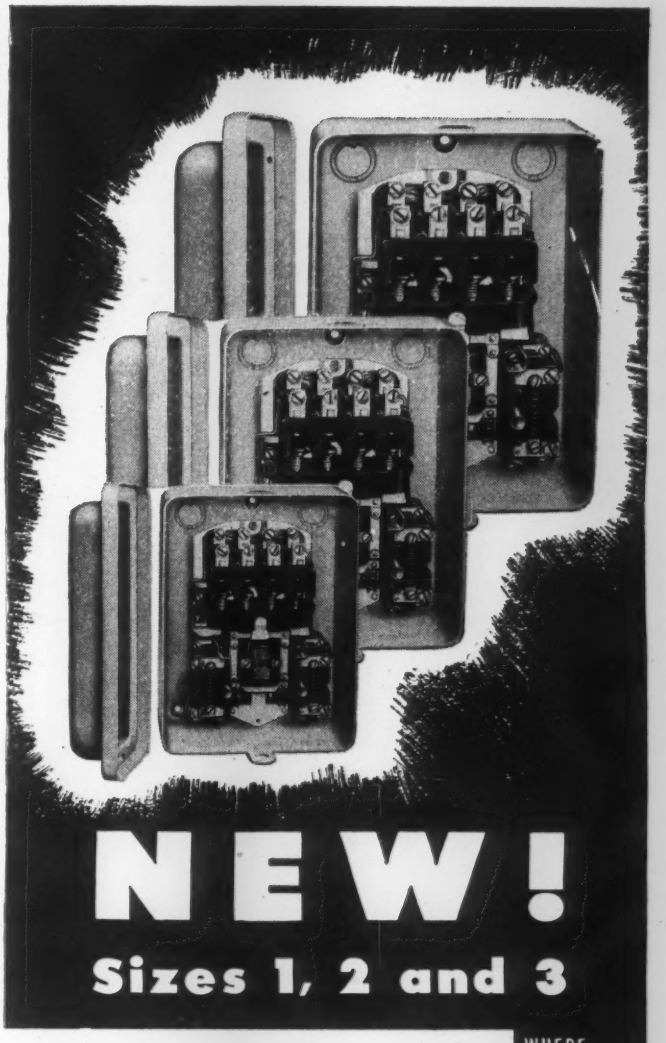
American Institute of Electrical Engineers. Summer general meeting to be held in Mexico City, Mexico. Additional information may be obtained from society headquarters, 33 West 39th St., New York 18. H. H. Henline is secretary.

June 21-25—

American Society for Testing Materials. Fifty-first annual meeting to be held at the Book-Cadillac Hotel, Detroit. Robert J. Painter, 1916 Race St., Philadelphia 3, is assistant to the secretary.

June 29-30—

National Warm Air Heating and Air Conditioning Association. Mid-year convention to be held at the Edgewater Beach Hotel, Chicago. George Boeddener, 145 Public Square, Cleveland 14, is managing director.



NEW!
Sizes 1, 2 and 3

Ward Leonard a-c Magnetic Starter Is Small in Size, Big in Performance

For fast, positive, dependable across-the-line starting of non-reversing motors, install Ward Leonard 4110 a-c Magnetic Starters.

Unit construction. Open or enclosed type. Accessible components. Double-break silver-to-silver main contacts. Thermal relays give overload protection. Local or remote control.

Ward Leonard Starters are "Result-Engineered." By modifying a basic design, Ward Leonard can give you the results of a special . . . for the cost of a standard.

Write for Bulletin 4110. Ward Leonard Electric Co., 58 South St., Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WHERE BASIC DESIGNS IN ELECTRIC CONTROLS ARE RESULT-ENGINEERED FOR YOU

WARD LEONARD
ELECTRIC COMPANY
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

PRIME MOVER

● Like the contractor's equipment that moves earth by the tens of tons, STEEL-FORGED* casters are rugged. That's why they're *prime movers* for hundreds of industries today. And *this* is why they're rugged:

HEAVY DUTY DOUBLE BALL BEARING SWIVEL RACEWAYS . . . FLAME HARDENED for extra toughness where wear and strain of heavy loads is concentrated.

FORGED STEEL TOP PLATE AND KING PIN make one integral unit that eliminates stretching and breakage at the vital point.

FORGED STEEL HEAVY SECTIONED SWIVEL YOKE eliminates caster fatigue due to overloads and bad floor conditions.

HYATT OR OILITE WHEEL BEARINGS revolving on HARDENED RACEWAYS provide easy rolling and long wheel life.

CHOICE OF WHEELS (NICRO-STEEL, Durastan or RUBBER) provides a wheel for every purpose.

FULL PRESSURE LUBRICATION to all moving parts.

THE RAPIDS-STANDARD CO., INC.
330 Rapistan Bldg., Grand Rapids 2, Mich.
Representatives in principal cities

Rapids-Standard

*T.M.

STEEL-FORGED CASTERS

DESIGN ABSTRACTS

Choice of Porcelain Enamel

WITH the wider use of porcelain enamel, finishes which give good appearance only are no longer sufficient; many service conditions require resistance to acids, and others to mild or even strong alkalies; some require resistance to boiling water and others to the action of freezing water. All of this gives emphasis to the statement that choice of the correct type of porcelain enamel should be governed by the service condition to be met.

Federal, state and county agencies often specify properties of materials which they purchase in terms of chemical analysis and other physical properties. Such specifications are worthless or meaningless in the case of porcelain enamel, for several reasons: The various manufacturers do not make public the basic formulation of their products; the products are difficult to analyze accurately; and lastly, regardless of chemical composition of the enamel, the final properties of the finish depend as much or more upon the processing during the enameling operation as upon composition of the frit.

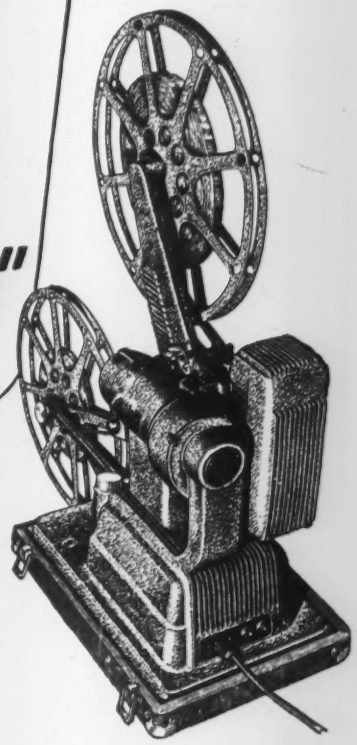
Basis of Specification

Specifications for porcelain enamel therefore are never on a basis of formulation, but are drawn up on a basis of appearance, freedom from significant imperfections and upon a basis of the service condition to be encountered. Resistance to acid attack, resistance to specified corrosion attacks, resistance to impact and other conditions may be described; minimum and maximum thickness may be specified if this is important on the finished product.

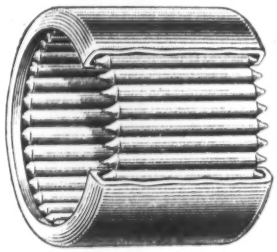
The Porcelain Enamel Institute has developed and approved certain tests covering the physical properties of enamels; many of these same tests have been approved and adopted by the Enamel Division of the American Ceramic Society.

The Enameled Utensil Manufacturers Council (an association of kitchenware manufacturers) has arrived at *minimum* standards of acid resistance and solubility of enamels for kitchenware, and has devised methods of testing. These specifications have been promulgated by the

A Needle Bearing Double Feature... "Efficient Operation" "Low-Cost Construction"



Torrington Needle Bearings in film reel, take-up spindle, sprocket drive mechanism and extension reel spindle contribute to the smooth operation and compact construction of the Revere Sound Projector, Model SP 16.



. . . compact Torrington Needle Bearings improve product performance, simplify design and manufacture.

TOP PERFORMERS in many modern products —home appliances, shop tools, automobiles and aircraft, industrial and farm equipment —Torrington Needle Bearings bring economy in fabrication and assembly.

Longer service life, lower power consumption, reduced maintenance and lubrication requirements, and a better load-weight ratio are among the outstanding contributions of high-capacity, lightweight Needle Bearings to product operation.

In manufacture, the compact unit construction of Needle Bearings simplifies the design of components of anti-friction assemblies . . . saving time and money in fabrication and assembly operations.

Our engineers will gladly help you adapt Torrington Needle Bearings to the requirements of your equipment. Call or write the nearest Torrington office.

THE TORRINGTON COMPANY

Torrington, Conn. South Bend 21, Ind.

District Offices and Distributors in Principal Cities

TORRINGTON *NEEDLE* **BEARINGS**

NEEDLE • SPHERICAL ROLLER • STRAIGHT ROLLER • TAPERED ROLLER • BALL • NEEDLE ROLLERS

12 Cr

OIL MAN'S Magic Number TO LICK CORROSION

. . . perhaps YOU have one, too!

DOWN in the oil fields, corrosion was playing havoc in gas condensate, high pressure wells. Equipment replacements were often needed at 30 to 40 day intervals.

Lebanon metallurgists and engineers made a searching analysis after which they came up with Circle L 12—a 12% Chromium Alloy. It brought good news to oil men because equipment life was extended appreciably. In some instances, examination disclosed no corrosion after more than a year.

The physical properties of Circle L 12 comply with the specifications of the American Petroleum Institute. It likewise meets ASTM specifications A-296-48 Grade 10.

What we have done for the oil industry, we can also do for you. Tell us your particular corrosion troubles. Perhaps one of the new Circle L Alloys will be your answer to longer equipment life.

LEBANON CIRCLE L 12

NOMINAL PHYSICAL PROPERTIES

API—Normalized and Drawn	
Tensile Strength	90,000
Yield Point	65,000
Elongation in 2"	18%
Reduction of Area	30%
Oil Quenched and Tempered	
Tensile Strength	105,000
Yield Point	90,000
Elongation in 2"	17%
Reduction of Area	35%

LEBANON STEEL FOUNDRY • LEBANON, PA.
"In The Lebanon Valley"
ORIGINAL AMERICAN LICENSEE GEORGE FISCHER (SWISS CHAMOTTE) METHOD

LEBANON *ALLOY AND STEEL* Castings

CIRCLE L

U. S. National Bureau of Standards as Commercial Standard CS 1100-44 (Sept. 25, 1944).

There are likewise available commercial standards covering the manufacture of porcelain enameled hot water storage tanks, viz., U. S. Bureau of Standards Commercial Standard CS 115-44 (Feb. 29, 1944).

Reflectance values, as measured on some particular instrument may be specified for white enamels or for light reflectors but "color" remains difficult to specify except by reference to a master sample.—*From a paper by J. H. Hansen Ferro Enamel Corp. presented at the ninth annual Porcelain Enamel Institute Forum, in Columbus, O.*

Present-Day Approach to Steel Selection

PROPER choice of steels is of fundamental importance to the automotive industry, and much work and study have been applied to this subject by many of the automotive organizations. Several of these organizations have a great deal of information and talent available and yet each have arrived at different steels which presumably fit their requirements best for applications that appear quite similar.

There is no complete agreement concerning the performance of any one steel except as to its mechanical properties. Such important considerations as tendency to distort, machinability, scaling tendency and the ease with which the scale may be removed, the forgeability, and in fact nearly all of the characteristics involved in shop fabrication, are subjects of considerable differences of opinion among users. Such differences, of course, are always due to lack of accurate facts and complete understanding of the process. It is these shop virtues, or lack of virtues, which frequently are the reasons for the differences in the choice of steels. Today we are in a far better position to judge the quality of steel for its mechanical performance than for its shop production behavior, even though we have no experience with this particular steel in the part. Recent experience with the introduction of N. E. steels has convinced us of this.

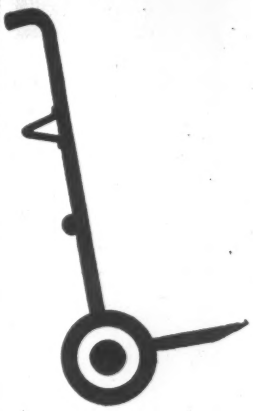
One thing is quite evident in comparing alloy steels used 25 years ago with those in use today in the automotive industry. We have been successful in using the steels which have the lowest first cost in the applications of our highest production parts. The steels most used 25 years ago

How Will You Have YOUR Tubing?

If *you* manufactured caulking nozzles, you'd solve most of your production problems on your purchase order! You'd merely specify OSTUCO Tubing, formed and fabricated to your own blueprint requirements, and OSTUCO engineers and craftsmen would turn out the finished parts that would simplify assembly operations.

Threading, Angle Cutting, Shaping, Flattening . . . these and a host of other production problems are being solved daily through the use of OSTUCO production-assistance. You can get the complete story, without obligation, by writing to the nearest Sales Office. Find out today how OSTUCO Tubing can cut your production time and costs.

WHAT'S YOUR PRODUCT?



HAND TRUCKS?

If you manufactured hand trucks, you could slash production costs by having OSTUCO provide tubing produced to your specifications, with the difficult jobs of bending, flattening and piercing already completed. Whatever your product, there's a good chance that OSTUCO Tubing can help produce it in less time, at lower cost.

BUS SEATS?

Bending, flattening, piercing and trimming . . . all four of these complicated fabricating and forming operations are handled by OSTUCO in producing a better bus seat frame for a nationally-known manufacturer. If your production costs are a problem, better turn to tubing—OSTUCO Tubing—for the solution.

OSTUCO

THE OHIO SEAMLESS TUBE COMPANY

***Plant and General Offices:* SHELBY, OHIO**

SALES OFFICES: CHICAGO, Civic Opera Bldg., 20 North Wacker Dr. CLEVELAND, 1328 Citizens' Bldg. • DETROIT, 2857 E. Grand Blvd. HOUSTON, 927 A M & M Bldg. • LOS ANGELES, Suite 200-170 So. Beverly Drive, Beverly Hills • MOLINE, 225 Fifth Avenue Bldg. • NEW YORK, 70 East 45th St. • PHILADELPHIA, 1413 Packard Bldg., 15th & Chestnut • ST. LOUIS, 1230 North Main St. • SEATTLE, 3205 Smith Tower • SYRACUSE, 501 Roberts Ave. • CANADIAN REPRESENTATIVE: Railway & Power Corp., Ltd., HAMILTON, MONTREAL, NORANDA, NORTH BAY, TORONTO, VANCOUVER and WINNIPEG.

THIS LITTLE BOOK MAY SAVE YOU BIG PRODUCTION MONEY!

- Tells how you can save from 10¢ to 20¢ a pound on high speed steels and get better results!
- Gives actual shop tests and comparisons!
- Practical data on heat treatment!
- Tells you how manufacturers are cutting production costs!

MOLYBDIC OXIDE — BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE" • CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

Climax Molybdenum Company
500 Fifth Avenue • New York City

MAIL COUPON TODAY!

CLIMAX MOLYBDENUM COMPANY MD-5
500 Fifth Avenue, New York 18, N. Y.

Please send me a copy of your free booklet

Name.....

Company.....

Address.....

were the SAE 6100 series, 3100 series, SAE 2300 series and the SAE 3200 and 2500 series. Today our greatest usage seems to be in the SAE 5100 series, the 4000 series, the 1300 series, the 8600 series, and the 4100 series. It is quite apparent that we have found it possible to use much cheaper alloy steels today than were used in our early experience.

An observation which has helped a great deal to simplify the choice of steels has been that in the hardness range from 200 to 400 and even 500 Brinell any of the standard alloy steels may be heat treated to give the same tensile properties as any other. The conclusion from this observation is that the most expensive and the least expensive alloy steels will give the same physical properties when properly heat treated. The joker in the statement, of course, is the clause "when properly heat treated." Parts with large sections cannot be given the proper heat treatment unless the steel has sufficient hardenability and if high hardenability is indicated it is not obtainable in the lowest priced alloy steels.

Quality Factors

There are other quality factors which must be mentioned. These are such factors as: The effect of electric melting of steels compared with the open hearth method; the tendency for some steels to become notch sensitive at room temperature and above; the quality that comes from proper cropping of ingots, good grain size control, and proper deoxidation of the melt; and the advantage of uniformity from heat to heat as well as within single heats.

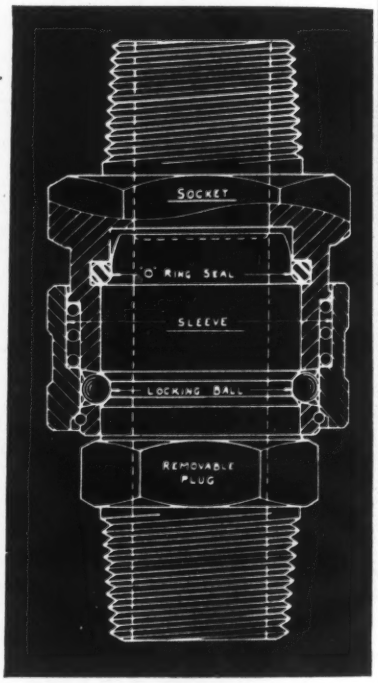
Since the tensile properties of the common alloy SAE steels are the same if properly heat treated, then the endurance limit of these steels should be the same since the endurance limit is related to the tensile strength. The endurance limit is a very important property of automotive steels because nearly all service requirements subject steels to fatigue stresses and the service performance of the steel is predicated on its ability to withstand fatigue loads. The usual approximation for endurance limit is 50 per cent of the tensile strength, but too often it is forgotten that this is the value obtained with highly polished surfaces free from notches. The endurance limit, if the steel has a machined surface, is less than 50 per cent of the tensile strength and if it has a surface produced by forging with no machining it is much lower.

For parts stressed in bending or

USE "O" RING SEALS

(The modern packing method)

FOR SIMPLICITY • RELIABILITY LOW COSTS • SPACE SAVINGS



"O" Ring Seals made possible this simple, straight through, quick disconnect coupling by THE HANSEN MANUFACTURING COMPANY of Cleveland, Ohio.

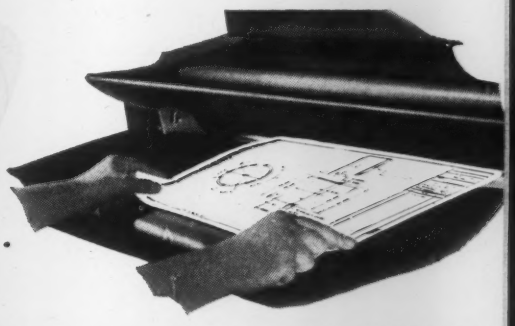
The end of the removable plug is tightly sealed by the "O" Ring when the plug and socket are in the locked position. Yet the plug can be removed and re-connected thousands of times without leakage.

Think of how complicated, bulky and costly this coupling would have been had conventional packings been used.

You, too, may have a problem that can easily be solved by using simple "O" Ring designs. For complete Engineering Data write for our "O" RING HANDBOOK.

PLASTIC and RUBBER
Products, Inc.
Box 431, Dayton 1, Ohio

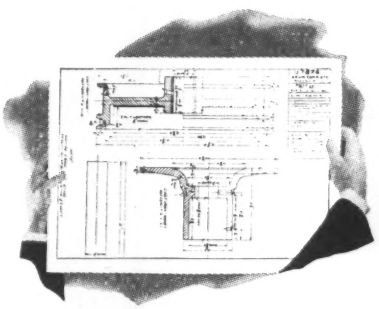
Made to help you get more out of direct process and blueprint reproduction



Gives more contrasty, more durable printing intermediates. Made with an extremely high-contrast silver emulsion and a tough, durable base, Kodagraph Autopositive Paper produces unexcelled printing intermediates—dense black images on purest white. Prints direct to positive . . . no negative step.

Assures more detail, more legibility in final shop prints. Made to save valuable originals from the wear-and-tear of quantity printing, Kodagraph Autopositive Paper—used for intermediates—makes possible blueprints and direct process prints of highest quality—sharp and crisp in every detail.

Kodagraph Autopositive Paper



Prints from more types of originals—direct to positive. Made to give superb prints from old, faded, worn, or opaque originals . . . blueprints or direct process prints . . . as well as good quality tracings, Kodagraph Autopositive Paper saves redrafting time and expense.

EASTMAN KODAK COMPANY
Industrial Photographic Division
Rochester 4, N. Y.

See for yourself . . . Your local blueprint service will be glad to produce Kodagraph Autopositive intermediates and, if you wish, direct process prints or blueprints from them. Or your own reproduction department can make prints on Kodagraph Autopositive Paper—in ordinary room light, on direct process or blueprint equipment, with simple photographic processing.

Mail coupon for FREE book

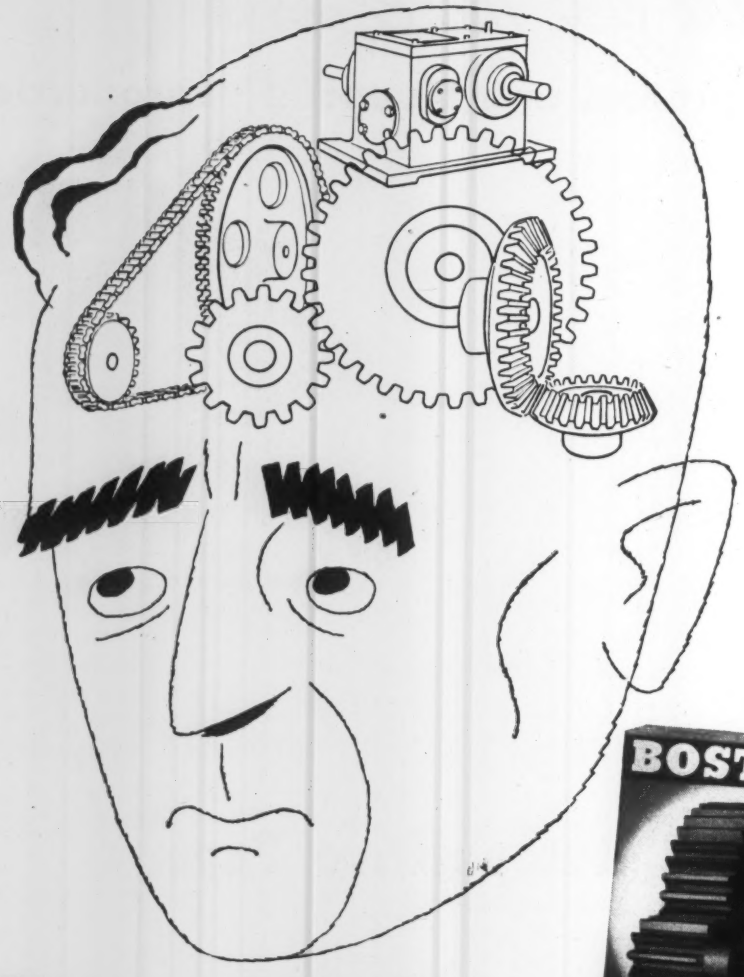
19

Eastman Kodak Company
Industrial Photographic Division
Rochester 4, N. Y.

Please send me a copy of "The Big New Plus" —your booklet about Kodagraph Autopositive Paper, and the other papers in this new Kodak line. I have
☐ direct process ☐ blueprint ☐ contact printer equipment.

Name _____
(please print)
Department _____
Company _____
Street _____
City _____
State _____

Kodak



Transmission problems?

This great data book has Your answers ——— Get it!

FREE This valuable data book which shows you how to make important savings in design, manufacturing and maintenance costs using Boston *Stock* Component Machine Parts. Contains 101 separate groups of products — gears, chain, sprockets, speed reducers, etc. — 4326 individual items — engineered, mass produced to custom standards for your application. Also contains much valuable working data for designers, engineers, maintenance men.

Name..... Position.....

Company.....

Street.....

City..... Zone..... State.....

One of the world's most complete lines
62 distributors in major cities

BOSTON GEAR WORKS
18 Hayward St., Quincy 71, Mass.

torsion it is considered good practice to have not less that 90 per cent martensite in the outer layer of any portion in the as-quenched condition. This layer need not have a depth of more than ¼ of the radius. For parts stressed mainly in tension, such as bolts, 90 per cent martensite to the center is desired.—*From a paper by W. E. Jominy, Chrysler Corp., presented at the recent annual meeting of the SAE in Detroit.*

Stress Concentrations in Magnesium Castings

CAST magnesium possesses a sufficiently high notch sensitivity to severe stress concentrations to warrant the avoidance of concentrated stresses wherever possible in cast structures. If several criteria for good design are observed, this characteristic of notch sensitivity will never be given an opportunity to manifest itself. The use of gradual contour changes incorporating blended sections and generous fillets, the use of through bolts rather than studs or cap screws where heavy loading is encountered, and the use of bosses around bolt holes are a few of the practices recognized as necessary to promote improved resistance to fatigue failures in magnesium castings.

In many applications it is possible to avoid the use of ribs and similar intricacies of design, thus avoiding potential sources of service fatigue trouble that have been encountered in castings of all the structural metals. One designer has managed to obtain 40 per cent greater rigidity in a given motor casting with no increase in the weight of the casting, by removing the ribs and increasing the section thicknesses. In addition, the nominal cyclic working stresses in the casting were considerably reduced and the stress concentrations were eliminated.

In many cases, however, where simplification in design is necessary to avoid stress concentrations, changes cannot be made without sacrificing weight. One of the advantages of designing in cast magnesium becomes apparent in such cases as these. If the troublesome design is in one of the heavier structural metals, or even aluminum, the weight advantage which can be realized if the casting is converted to magnesium provides more than sufficient weight saving needed to blend out the design into a more serviceable casting. —*From a paper by George H. Found, magnesium laboratories, The Dow Chemical Co., presented at the forty-ninth annual meeting of ASTM.*

"Heard his story about Fiberglas*-reinforced plastics?"

He's saying that with Fiberglas reinforcements you can design and produce a laminated product that is:

Light in weight and extremely tough

Resistant to corrosion and rust

Permanently colored: Eliminates original cost of surface finishing—no maintenance cost.

Easy to fabricate: Can be formed with either high or low-pressure laminating equipment—at minimum tooling cost.

Economical: Fiberglas reinforcements are available, today, priced lower than most commonly used laminating reinforcing materials.

Want to know more about these materials and processes that can help you expand your markets and lower your fabricating costs on complete finished or component parts? Then write today for a copy of "Fiberglas-Reinforced Plastics" Manual A9.3.1. It contains information on the properties, applications, economics and typical methods used in fabricating products of plastics reinforced with Fiberglas Mats, Cloths and Fibers . . . Owens-Corning Fiberglas Corporation, Dept. 808, Toledo 1, Ohio. Branches in principal cities.

In Canada: Fiberglas Canada Ltd., Toronto, Ontario.

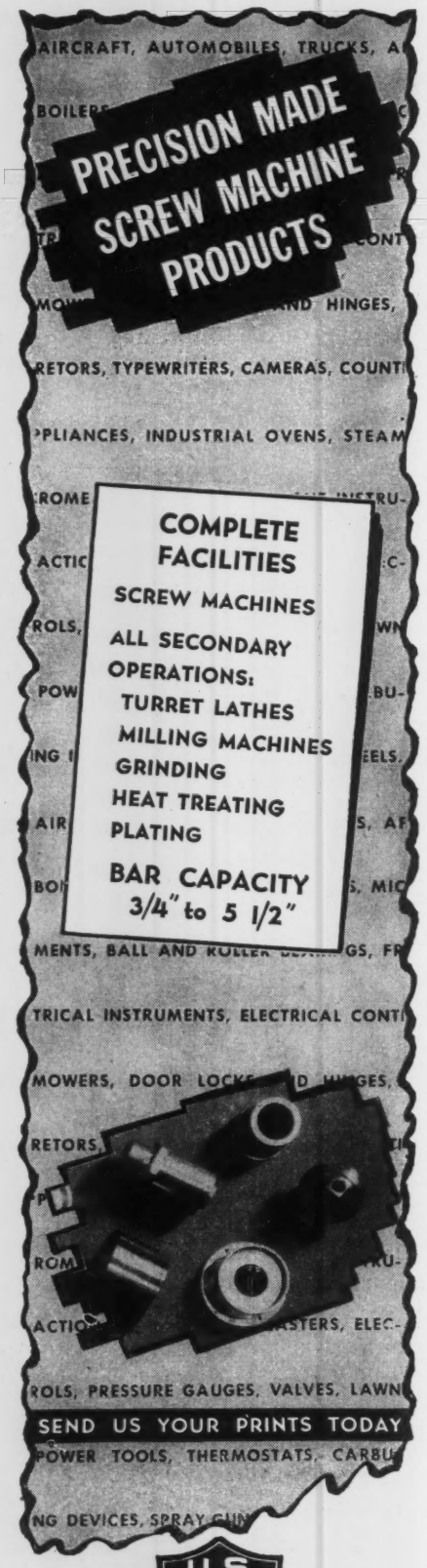
OWENS-CORNING

FIBERGLAS

T.M. REG. U.S. PAT. OFF.

PLASTICS REINFORCEMENTS

*Fiberglas is the trade mark (Reg. U.S. Pat. Off.) for a variety of products made of or with glass fibers by Owens-Corning Fiberglas Corporation.



CHICAGO
DETROIT
INDIANAPOLIS

U·S AUTOMATIC

NEW YORK
PITTSBURGH
PHILADELPHIA

U·S·Automatic Corp.
Amherst, Ohio

NEW MACHINES

And the Companies Behind Them

Agricultural

LOADER. Attaches to small tractor. Hydraulically powered. Pump valve and tank in single unit. New Method Equipment Co., Indianola, Iowa.

Commercial

GASOLINE PUMP. Four-piston positive-displacement meter; dust-proof computing head; rubber-sealed removable doors; mechanical motor switch; die-cast aluminum nozzle. Shipping weight, 500 lb. Gilbert & Barker Mfg. Co., West Springfield, Mass.

PACKING SCALE. Over-under balance beam type; heavy duty; capacity, to 30 lb.; accuracy, to ¼-oz. Air-controlled dashpot; over-under head on extra high pillar. Detecto Scales, Inc., Brooklyn 1, N. Y.

Domestic

HOME REFRIGERATOR. Seven cubic foot. Built-in control protects against line overloads. One-piece turret top, box type door, three-way door latch. Finish, synthetic white enamel. Breaker strips of patterned Micarta. Seven positions on coldness control. Westinghouse Electric Corp., Pittsburgh 30.

ELECTRIC IRON. Aluminum sole plate. Large plastic, pancake-shaped heat-control dial. Heating element sealed in steel. Two weights, 3¼ and 4½ lb.; 110-120 volts, a-c, 100 watts. The Hoover Co., North Canton, O.

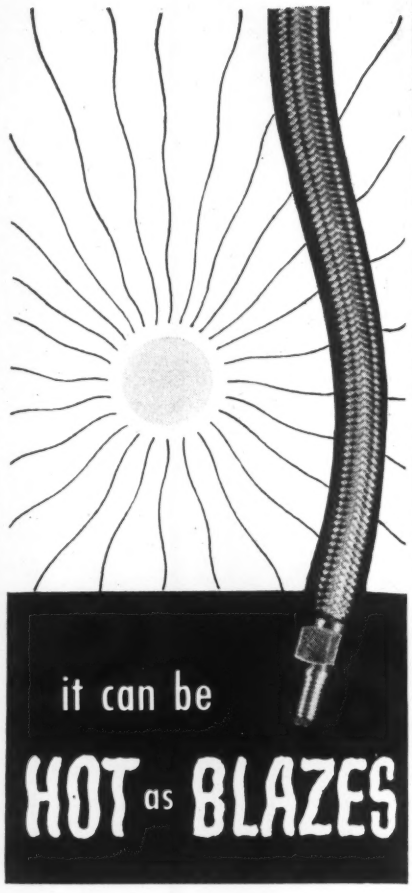
ELECTRIC FAN. Portable; 10-inch. Shaded-pole induction motor, 60-cycle, 105-120 volt, a-c. Switch on motor housing; weight 4½ lb. G-M Laboratories Inc., Chicago.

OIL BURNER. Capacity, 0.6 to 6.0 gallons per hour. Pump, oil strainer and pressure regulator valve in one unit; oil line, air spinner and ignition points in removable draw assembly. Flange-mounted, ⅛-hp motor; specially designed fans, air spinners and chokes. United States Radiator Corp., Detroit 31.

VACUUM CLEANER. Suction, waterlift of 47 inches. Powered by ½-hp motor enclosed in burnished aluminum top along with air filter. Polished cast aluminum base on four casters. Weight, 29 lb. Breuer Electric Mfg. Co., Chicago 40.

Industrial

DUST COLLECTOR. Enclosed cabinet type; cylindrical felt filter bag; air lock between discharge hopper and



yet

Titeflex

will stand up!

TITEFLEX All-Metal Flexible Tubing can be furnished with innercore made of any one of five different metals to meet the temperature requirements of practically any application. The top working temperatures of tubing made from these five metals are as follows:

Brass	**250° F.**
Bronze	**325° F.**
Monel	**800° F.**
Stainless	**800° F.**
Inconel	**1700° F.**

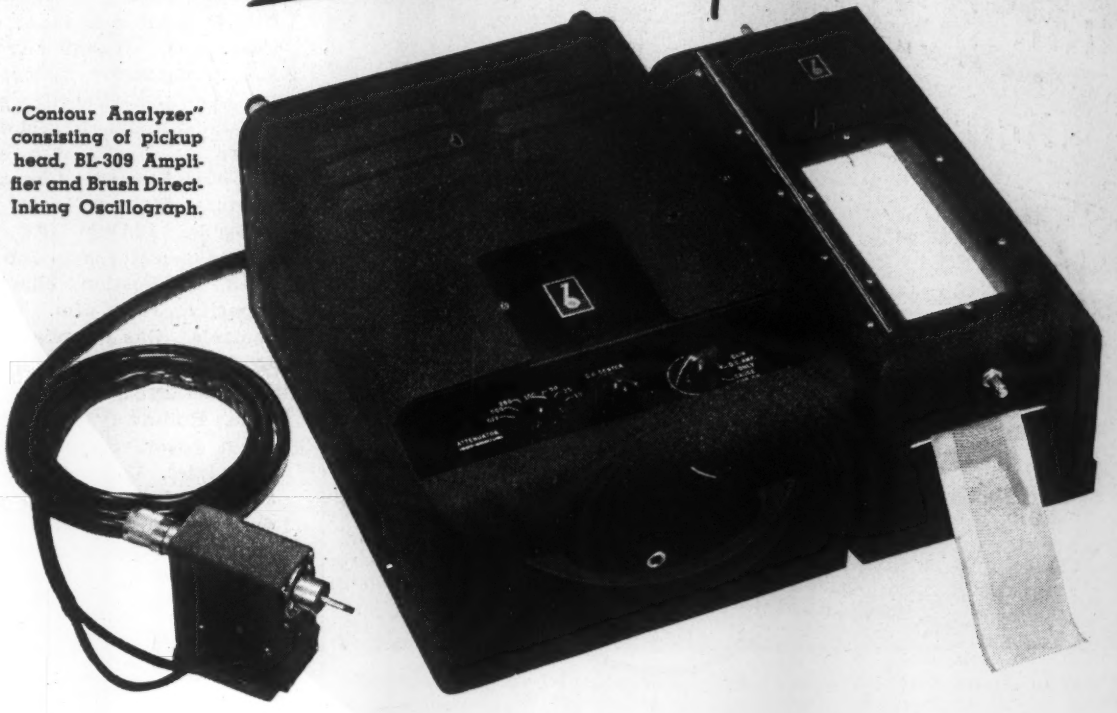
Remember, too, that TITEFLEX is constructed entirely of metal—with no packing to disintegrate because of heat or other abuse. TITEFLEX engineers will gladly assist you in selecting exactly the right type tubing to meet your temperature requirements, as well as other operating conditions. Literature on request.

Titeflex, Inc. 532 Frelinghuysen Ave., Newark 5, N.J.

Exclusive Manufacturers of Titeflex high quality products for more than 30 years

Sales Offices: CHICAGO CLEVELAND DETROIT PHILADELPHIA LOS ANGELES BOSTON SAN FRANCISCO TORONTO

a new Brush development—



"Contour Analyzer" consisting of pickup head, BL-309 Amplifier and Brush Direct-Inking Oscillograph.

"Contour Analyzer"

records and measures displacements from 10 to 10,000 microinches!

The "Contour Analyzer" is an instrument designed to record small displacements from a given reference point or line. Its sensitivity is such that movements as small as 10 microinches can be readily recorded and measured on the chart of the Brush Direct Inking Oscillograph. It can be used in a great number of applications involving small displacements, static or dynamic. Typical uses are as a recording micrometer, vibration recorder, pressure and force recorder etc. In particular, the instrument lends itself well to the measurement of errors in the contour of irregularly shaped sections.

Specifications

Displacements measurable	10 to 10,000 **microinches**
Frequency Response (overall)	Essentially uniform d-c to **100 cps**
Feeler Arm Travel	⅛" approximately
Feeler Arm Force	Adjustable
Amplifier Dimensions	Length, 17¼"— Width, 11"— Height, 7½"
Amplifier Power Requirements	100 watts
D-C Amplifier section of BL-309 "Contour Analyzer" Amplifier, used with Brush Direct Inking Oscillograph:	
Frequency range	d-c to 120 cps
Input impedance	5 megohms
Normal Sensitivity	150 mv RMS per chart mm

Write or call

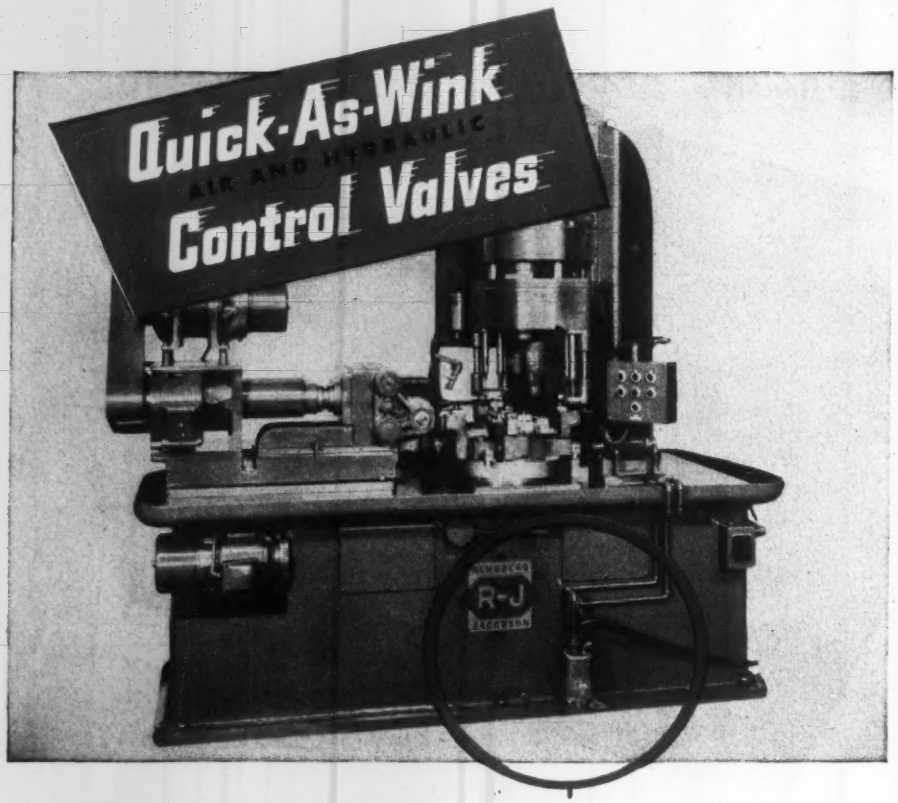
THE Brush DEVELOPMENT COMPANY

3405 Perkins Avenue • Cleveland 14, Ohio, U.S.A.

MAGNETIC RECORDING DIV. • ACOUSTIC PRODUCTS DIV.

INDUSTRIAL INSTRUMENTS DIV. • CRYSTAL DIVISION

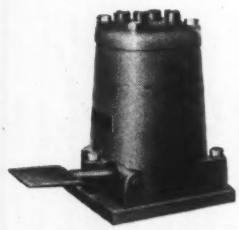
Canadian Representatives: A. C. Wickman, (Canada) Ltd., P. O. Box 9, Station N, Toronto 14



For Machines and Machinery of All Kinds

● Positive, fast-acting and dependable, Quick-As-Wink Control Valves have demonstrated their outstanding superiority under a wide variety of conditions. All operating parts are in pressure balance eliminating any tendency to creep or crawl. The U-shaped packers are expanded by pressure and seal tightly preventing leakage. There is no lapping—no grinding—no metal-to-metal seating. Every valve is a quality product—precision made and individually tested. They give users a maximum of long and trouble-free service.

Furnished in hand, foot, pilot, solenoid and diaphragm operated designs for controlling all types of air and hydraulic equipment. Let us work with you on your requirements!



Quick-As-Wink Foot Operated Air Valves

The 3401-RA4 pictured above is a 4-way two position valve for controlling double acting air cylinders. Ideally used with brakes, shears, presses, forging machines, etc., because the operator has both hands free to handle the work. Furnished in 3/8", 1/2", 3/4", 1", 1 1/4" and 1 1/2" sizes. 3-way and 4-way neutral position or regular actions—for air up to 125 lbs. pressure and 150° F.;—but send for a catalog today and get *full* details about the *complete* line.

Quick-As-Wink Control Valves

THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

Manufactured by **C. B. HUNT & SON, Inc.,** *Salem, Ohio.*

Engineering and Sales Representatives in the Principal Cities

collecting drum. Blow ring is roller chain driven. Pulverizing Machinery Co., Summit, N. J.

AIR CIRCULATOR. Wall or post mounted. 35-inch aluminum propeller. Two-speed, dynamically balanced 1/6-hp capacitor motor; pushbutton operated. Propeller guards are expanded metal. Height adjustable. Rated at 10,000 cfm at 4 feet. Fresh'nd-Aire Co., Chicago.

INDUSTRIAL HEATER. Direct gas fired. Capacity, 125,000 Btu per hour. For temperatures to 350 F. Brick-lined combustion chamber. Fan capacity, 1000 cfm. Temperature controls. Gas Appliance Service, Inc., Chicago.

DUST COLLECTOR. Self contained, unit type. Roll-away bin with clamp-down cover. Suction capacity on 6-in. inlet, 1394 cfm at 3.2 static suction. 1½-hp, 3450-rpm, cont.-duty motor direct drives fan. Cyclone separator; spun-glass second-stage filter. Aget-Detroit Co., Ann Arbor, Mich.

Manufacturing

MULTIPLE-SPINDLE DRILLER AND TAPPER. High-speed, sensitive. Quick speed-change mechanism; reversing motor drive. Combination hand and foot feed or hydraulic power-operated feed. National Automatic Tool Co. Inc., Richmond, Ind.

PIPE AND TUBING CUTTER. Portable. Power-driven rollers; automatic stop-start action. Pipe diameters from ⅜ to 4 in.; ½-hp, 110-volt, ac-dc motor; direct gear drive to rollers; gears self lubricating. Quijada Tool Co. Inc., Los Angeles 32.

SHAPE WELDER. Submerged melt process; welds to any outline from templet. Welding head current capacity, 2000 amps; operating area, 34 by 80 in. Stepless speed control; welding speeds from 4 to 40 or 11 to 100 in. per minute. The Linde Air Products Co., Unit of Union Carbide and Carbon Corp., New York 17.

HYDRAULIC PRESS. Hot-plate type; 30-ton; for plastics laminating, plastics and rubber molding, powder metal pressing, etc. Electrically-heated, thermostatically-controlled platens; enclosed hydraulic system; dual pressure pump. The M & N Machine Tool Works, Inc., Clifton, N. J.

SPOT WELDER. Welds up to ⅛-in. combined metal thickness. Enclosed in cast aluminum case. Replaceable special alloy tips; silicon steel and copper transformer with spun-glass insulated magnet wire. Weight, 23 lb.; 110 or 220 volts. Greyhound A.C. Arc Welder Corp.,

FELT SEALS RETAIN LUBRICANTS, EXCLUDE DUST

Two Basic Types of Felt Seals, Applicable in a Wide Variety of Designs, Solve Most Sealing and Packing Problems

The unusual and unique properties of felt make it especially valuable in sealing and packing applications. Such uses are increasing steadily, as more and more engineers and designers appreciate the simplicity of application, reliability of performance, and long life of felt. For any machines in which it is necessary to retain bearing lubricants, and feed them automatically and uniformly as needed, or from which dust, fumes or moisture must be excluded, felt seals and packings merit your consideration.

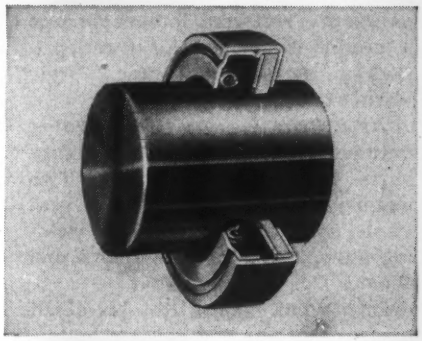
PHYSICAL CHARACTERISTICS

The chief physical characteristics of felt that make it so highly suitable for seals are absorption capacity, low coefficient of friction, and resiliency. Oil absorption capacity is high, and is largely a function of felt density. The coefficient of friction averages 0.22 for dry felt against steel, which is reduced to 0.15 when the felt is pre-saturated with oil of 41.2 Saybolt viscosity at 210°F. Because of its resilience, felt maintains a constant sealing pressure regardless of wear, end-play, minor mis-alignment or out-of-round conditions of metal shafts and assemblies. Felt seals will never fail through aging, embrittlement, or distintegration.

TWO TYPES OF SEALS

Plain Felt Seals. These are precision-cut washers, produced by American Felt Company, your cutter, or in your own plant, with a tolerance of .005". These are cut from standard types of S.A.E. Felt, and may be pre-saturated with lubricant before assembly. The lubricant employed is generally one higher in viscosity than that which is to be retained. Such seals have only two limitations: they should not be used to retain oil of extremely low viscosity, nor to retain pressurized lubricants. For such services, the laminated seal is recommended.

Laminated Felt Seals. In these, the plain felt seal is combined with one or more impervious septums of 1/64 to 1/32 inch sheet Hycar. The felt may be of the same density throughout, or felt of different densities may be used on opposite sides of a septum. Thus a laminated seal can have felt of high density and oil-retention capacity on one side, and on the other side a lower density felt for dust exclusion. An example of this is seen at (a) in the drawing, which shows a single-unit washer that combines lubricant-retention, sealing, and dust-exclusion. The impervious septum may also be on only one side of the washer, as in (b). The multiple laminations of (c) to (e) inclusive are further modifications, developed for progressively more difficult mechanical sealing operations.



IMPREGNANTS

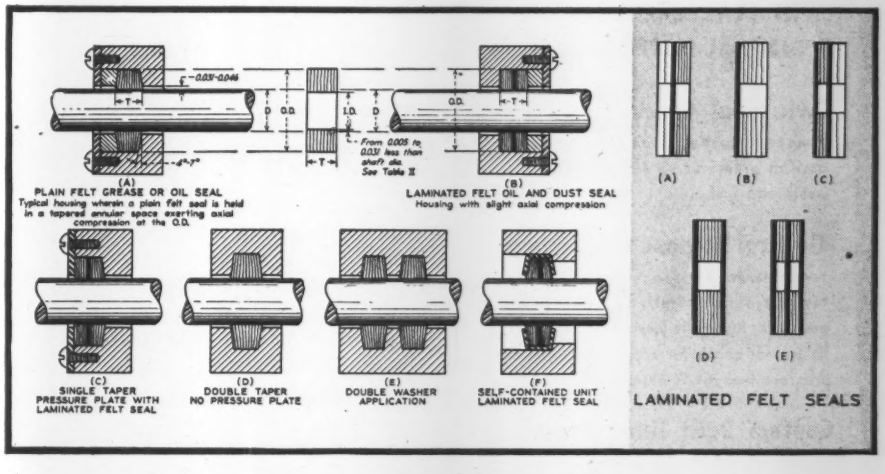
Both plain and laminated felt seals may be impregnated with standard grades of oils and greases, or special treatments may be used to meet unusual conditions.

SELECTION

Felt seals, plain or laminated, are recommended where operating temperatures lie between −60° and 250°F. and where peripheral shaft speeds do not exceed 2000 feet per minute. Since felt is an engineering material, thoroughly understood and standardized, selection of the proper type to meet any given conditions within the above range can be made with complete confidence.

COLLABORATION

American Felt Company engineers will gladly collaborate with you in design of seals and selection of the proper type of felt. The material in this advertisement is a condensation of data given in American Felt Company Data Sheet No. 11, "Felt Seals, Their Design and Application." This contains additional technical information, such as tables showing oil absorption capacity, and dimensional tolerances and degree of housing compression for plain and laminated felt seals. This eight-page Data Sheet is the outstanding paper on this subject. Write for it on your company letterhead.


(A)
PLAIN FELT GREASE OR OIL SEAL
Typical housing wherein a plain felt seal is held in a tapered annular space exerting axial compression at the O.D.
(B)
LAMINATED FELT OIL AND DUST SEAL
Housing with slight axial compression
(C)
SINGLE TAPER PRESSURE PLATE WITH LAMINATED FELT SEAL
(D)
DOUBLE TAPER NO PRESSURE PLATE
(E)
DOUBLE WASHER APPLICATION
(F)
SELF-CONTAINED UNIT LAMINATED FELT SEAL
LAMINATED FELT SEALS

American Felt Company

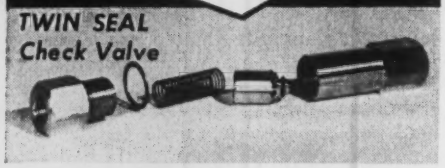
TRADE MARK

Engineering and Research Laboratories: Glenville, Conn.
PLANTS: Glenville Conn.; Franklin, Mass.; Newburgh, N. Y., Detroit, Mich.

SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, St. Louis, Philadelphia, Atlanta, Rochester, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal

LEAKY check VALVES?

TWIN SEAL Check Valve



GENERAL PURPOSE HAND PUMP

HOLD UP TO 20,000 psi

with

TWIN SEAL CHECK VALVE & GENERAL PURPOSE PUMP

Twin Seal Check Valve
assures absolutely leakproof performance at pressures up to 20,000 psi . . . even with grit.

General Purpose Hand Pump
recommended for use in test stands . . . for hydrostatic testing . . . source of power for hydraulic jacks, small hydraulic presses or similar applications where pressure leakage is objectionable.

Custom Built Hand Pumps
may be an adaptation of the general purpose pump illustrated, or special pumps fabricated entirely of bar stock parts machined from alloys to meet specific conditions.

Write for Bulletin M-5

MANSFIELD & GREEN
1051-3 Power Ave. CLEVELAND 14, O.

Brooklyn 6, N. Y.

ETCHING MARKER. For electrolytically etching trade marks, part numbers, etc., on all metals. Uses no acids. Rheostat and ammeter equipped. Removable cover. Size, 9 by 11 by 7¾ inches. Crown Industrial Products Co., Chicago 15.

TOOLMAKER'S MICROSCOPE. Standard magnification, 30X. Reticule in eyepiece contains 90-deg. hairline cross and 60-deg. angle cross for thread measurements. Vertical adjustment by spiral rack and pinion. Understage illumination for shadow images and surface illumination for reflected images; image is produced on clear glass reticule. George Scherr Co. Inc., New York 12.

MULTIPLE SPOT WELDER. For welding automobile dash panels; eighty parts per hour. Automatic. Two water-cooled transformers; seventy-six hydraulically operated welding guns. The Federal Machine and Welder Co., Warren, Ohio.

POWERED WORK TABLE. Rotates about central shaft having electric motor-driven gearbox. Universal-jointed arm connects drive unit to machines mounted around rim of table. Three speed ranges. Roto-Table Co., Dayton 3, O.

Materials Handling

BELT CONVEYOR. Composed of drive section and takeup section. Sections can be added to increase length. Heavy-gage steel flights and chain. Sermat Conveyor Corp., Chicago 36.

LIFT TRUCK. Ram type, 20-ton; electric, battery powered. Elevating height, 10½ ft.; max. speed under load, 5 mph. Minimum steering radius, 12 feet. Weight, 6500 lb. Magnetic holding brakes; drive and hoist motors glass wound, silicone grease lubricated. The Yale & Towne Mfg. Co., Philadelphia.

PALLET-SWITCHING TRUCK. Hand type. Loads to 4000 lb. Platform, 48 in. square, is double row of rollers. Platform height, 5½-in. Hinged stops; self-contained hold-up device in handle. Lyon Raymond Corp., Greene, N. Y.

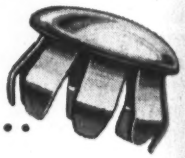
Metalworking

TUBING MARKER. Stamps 1, 2, 3 or 4 sides of round or shaped bar or tubing on same run up to 300 fpm. Sizes, ⅜ to 2 in. Powered by ⅓-hp motor. Replaceable segments, interchangeable type. Weight, 700 lb. Pannier Bros. Stamp Co., Pittsburgh 12.

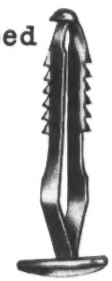
BAND SAW. Cut-off capacity, metals to 5 by 10 in. Operates and shuts off automatically. Hydraulic feed control; box type frame; bed set on three-point base. Three blade

If you have a Fastener Need . . .

that's suitable to Volume Production...



It may pay you to let our Design Engineers have a hand in it.



They have helped many manufacturers

★ CUT COSTS

★ SPEED PRODUCTION

★ TURN OUT FINER FINISHED PRODUCTS

UNITED-CARR FASTENER Corp.
CAMBRIDGE 42, MASSACHUSETTS

MAKERS OF DOT FASTENERS

Gear Up with

the Dependable Metals

Brass and Bronze

MODERN engineering research is constantly finding new uses for the "Metals of the Ages" . . . cast Brass and Bronze. From tiny gear wheels in washing machines to massive gears in heavy machinery . . . for plumbing fixtures, hardware, pump parts, bearings, bushings, valves . . . these alloys of copper serve the engineer as nothing else will.

Wherever high strength and freedom from corrosion count . . . and where non-magnetic qualities must be combined with them . . . brass and bronze provide the answer.

Architects and designers, too, rely on castings of these warm, rich metals . . . to build beauty and character into their creations.

You can get Brass and Bronze castings NOW!

The Brass and Bronze Ingot Institute (formerly Non-Ferrous Ingot Metal Institute) suggests your local foundry for help with all casting problems.